SEPTEMBER-NOVEMBER 1982 PRICE 60p

# Electronics

## THE MAPLIN MAGAZINE

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Electronics
THE MAPLIN MAGAZINE

# A NEW ELECTRONICS EXHIBITION IN LONDON

The end of the year is always a busy time for exhibitions and two of the biggest will be happening during the next three months. First, in September, is the 5th Personal Computer World Show which is the biggest of the personal computer exhibitions and is being held this year at the superb new Barbican Centre. We'll be there with a whole host of new software and lots of Atari computers for you to play with.

The second show, coming in November, is the one we're all excited about, here at Maplin. It's the Electronics Hobbies Fair, a brand new show, that is going to be very different from anything you've ever seen before. As well as the usual electronics stands, there will be computers, model control, amateur radio, CB and practical hi-fi.

But the big plus about this show is that the organisers have really gone to town to provide you with dozens of extra exciting things to see and do. Unfortunately, we can't be more specific at this time, as one or two of the events are not yet finalised, but I can assure you that it is going to be a real feast of good things.

In addition to all that, the organisers have arranged for special rail fares to be available and they've laid on special buses to get you to the exhibition site from the nearest rail station.

This exhibition, too, is being held at a brand new site in the grounds of Alexandra Palace. It's called the Alexandra Pavilion and I know you'll be impressed with the light, airy and relaxed atmosphere in the Pavilion. On our stand we'll have on show most of the projects from the first year of this magazine, a huge display of Atari computers for you to use, and we'll have our 1983 catalogue on sale.

At both shows you'll be able to pick up application forms for our new credit card, Mapcard. We know that Hobbycard was extremely popular for the short time that we were able to offer it and now Mapcard which is Maplin's own credit card takes over from where Hobbycard left off. Full details of this great new scheme are given on page 39.

***Cover Picture***

*All the satellite pictures in this issue of the magazine, including the front cover, were provided by the NOAA (National Oceanic & Atmospheric Administration), Satellite Service, Washington DC, USA. Our many thanks to them.*

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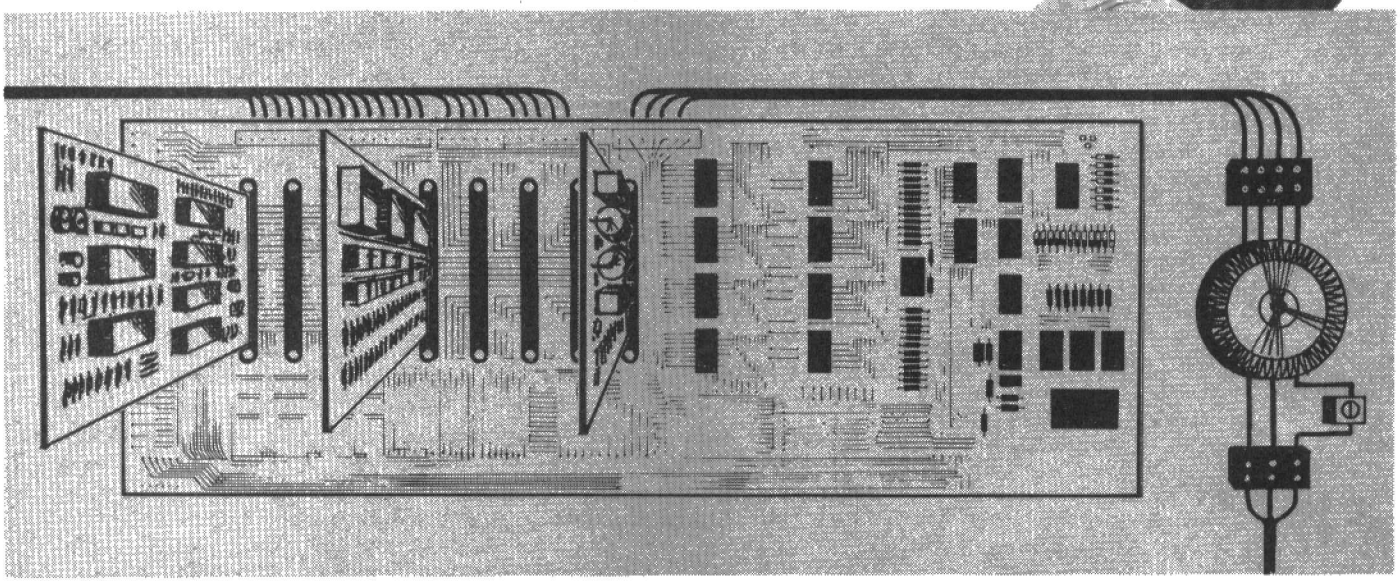
# THE MAPLIN Digi-Tel TELEPHONE EXCHANGE

*by Robert Kirsch*



- ★ **Expandable from 4 up to 32 extensions**
- ★ **No call can be interrupted or overheard by another caller**
- ★ **Standard 2-wire connection to telephones**
- ★ **All phones powered by the 2-wire line. A mains connection is only required at the exchange**
- ★ **May be used with either our low-cost push-button telephones, or standard British Telecom phones**
- ★ **Up to sixteen telephones may be in use at any one time (in full 32 extension system)**

A telephone exchange of any capacity has not, until now, been a feasible project for the amateur constructor, due to its size, power requirements, cost, and non-availability of electro-mechanical switches. This article describes the building of a complete 16-line internal automatic exchange using solid state switching techniques, and powered from the mains supply. The system is suitable for use in the home or in a small business or factory, and requires only two wires from each extension to the exchange unit.

Maplin are making available a low cost, modern styled, push-button telephone for use with this system, although ordinary British Telecom type telephones with loop disconnect dialling and AC ringing can be used. The exchange may be equipped with as few as four or as many as thirty-two extensions (the addition of the second sixteen lines, and possible interfacing between this exchange and a switchboard and other exchanges will be described in later articles).

## How It Works

First, the operation of the standard telephone should be studied to consider its' requirements in relation to the exchange being used. Figure 1 shows a simplified block schematic of an ordinary telephone, and it will be seen that when the handset is lifted the transmission circuit produces a loop across the line (indicating to the exchange that a call is about to be made, or that an incoming call has been answered). This loop is interrupted by the dial contacts, the number of interruptions being dependent on the number dialled, i.e. when 1 is dialled the circuit is interrupted once, and when 0 is dialled it is interrupted ten times. An AC bell is used for incoming calls, and this is connected across the line via a capacitor to prevent a DC loop when the handset is on its rest.

## Extension Line Circuit (ELC)

This circuit consists of two main parts, one for incoming and the other for outgoing cells. A block diagram of the ELC is shown in Figure 2 and a circuit diagram in Figure 3.

## Outgoing Calls

When the telephone handset is lifted, the loop produced across the line is detected by TR5. This transistor is biased on by the current flowing through R11, and this current (via L1)

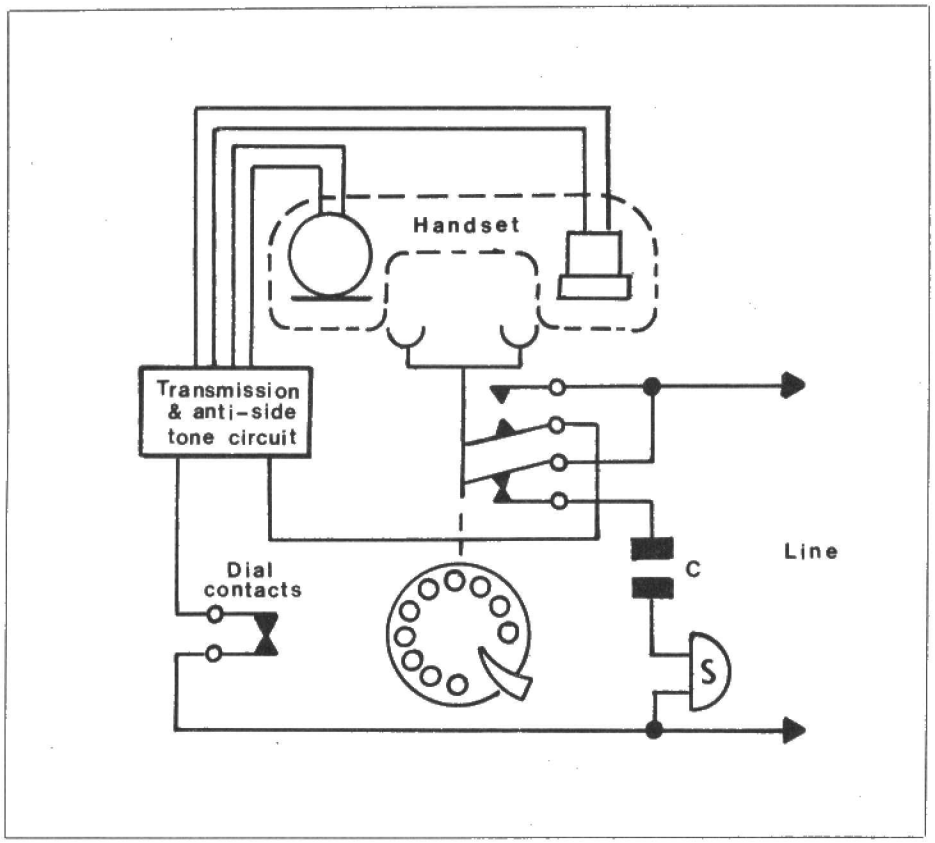



Figure 1. Block diagram of a typical telephone.

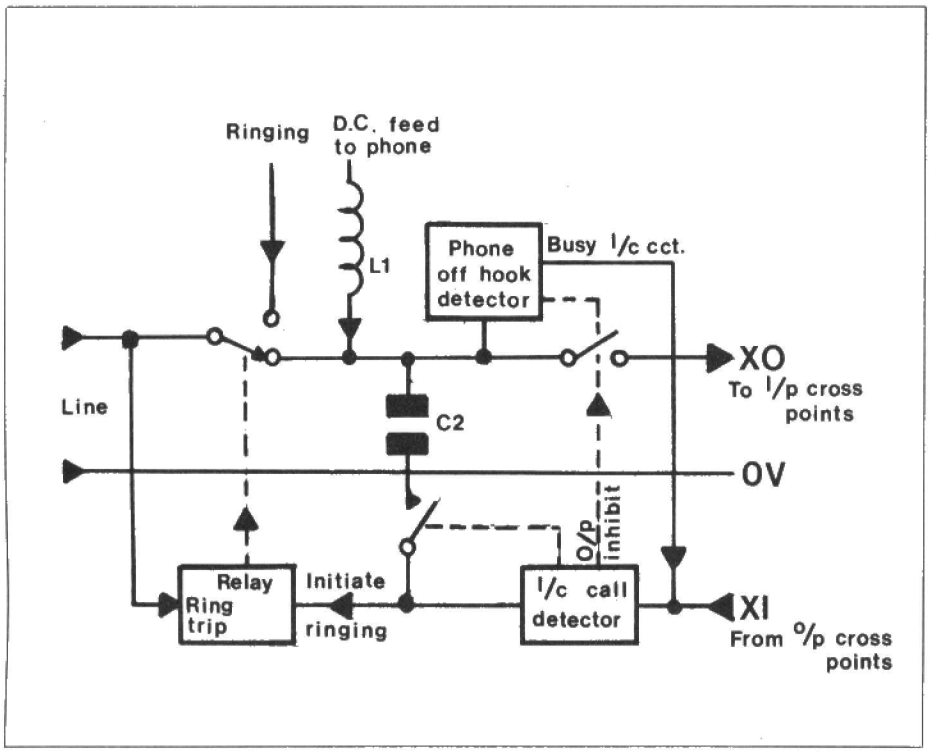



Figure 2. Block diagram of an Extension Line Circuit (ELC).

also provides the DC supply needed for the telephone transmitter (microphone). The operation of TR5 can be inhibited by TR4 to prevent a calling condition when the handset is lifted during an incoming call. TR5 switches the voltage present across the line through D2 to the output of the ELC. This voltage varies between 5 and 10 volts dependent on the line resistance and type of telephone in use and is modulated by audio signals. At the same time TR2 switches a high impedance 15V to the ELC output via D1 and R2, and this is used as a calling condition. When the output is terminated by a Connect Circuit the 15V is shunted, thus removing the calling voltage and preventing a second Connect Circuit (CCB) from switching to the ELC. When a call is being made a voltage is also fed to the ELC input via D4, to prevent incoming calls switching to the circuit while it is in use.

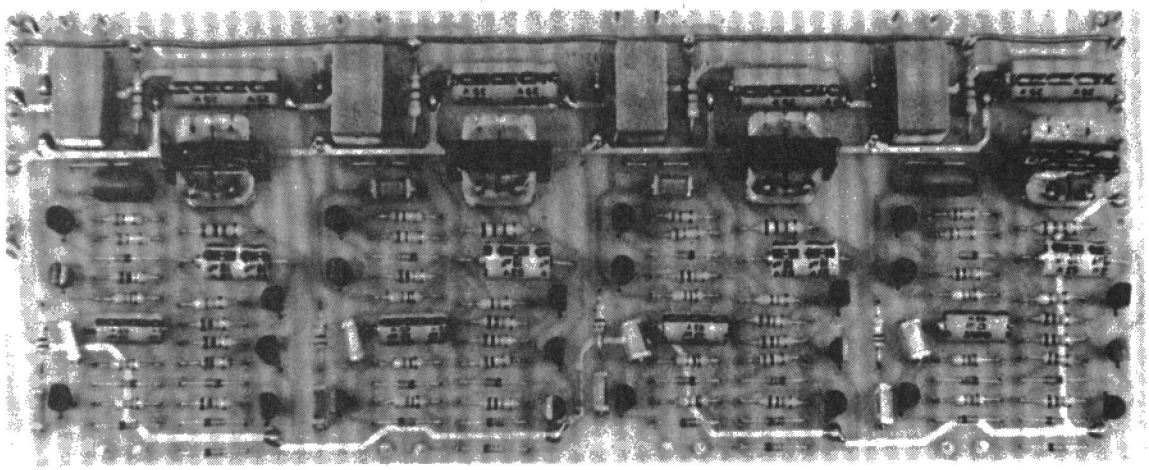
## Incoming Calls

When a call is made, the voltage at the output of the calling ELC is switched through the system to the input of the ELC being called, and this voltage initiates ringing to the called extension. When a voltage is applied to the ELC input TR1 is biased on, and this connects the audio transmission path through to the line circuit of the called extension via C2. At the same time TR3 is turned on, and its collector is pulled towards 0V. This causes TR4 to turn on and inhibit an outgoing call condition as previously described. When the collector of TR3 goes low it also pulls the emitter of TR6 low via D6. This transistor is pulsed into conduction by C4, and causes the relay RLA to operate. The change over contacts RLA/1 switch the line from the normal path to the 100V square wave ringing supply, which rings the bell of the called extension. The 100V supply is also fed via R12 and R13 to the base of TR6, and holds the transistor in the conducting mode.

Ringing tone is provided for the calling extension by coupling a small amount of the ringing supply back to the input of the ELC via C1 and R1. The 100V ringing supply is fed from a fairly high impedance, and when the line is terminated by the handset of the called extension being lifted the voltage fed to the base of TR6 is reduced, and the transistor ceases to conduct, causing the relay to release, the ringing to stop, and the transmission path to be switched through. If the handset of the called extension is replaced at the end of a conversation before that of the calling extension, the ringing will not restart, as the emitter of TR6 is still low and C4 remains charged and is thus unable to pulse the transistor into conduction.

## 4 by 4 Crosspoint IC 45100

All the main switching in the telephone exchange is carried out by the 45100 IC, and it is important to understand how this IC works before going on to describe the connecting circuits. The 45100 is a 4 by 4 crosspoint switch that has 4X and 4Y connections. This means that there are a total of sixteen switches in each IC. Each switch is a dual direction analog transmission gate, and is turned on and off under the control of the DATA, STROBE, and ADDRESS inputs to the chip. A particular switch is controlled by setting up its code on the four ADDRESS lines A-D and applying a strobe pulse to the chip. If during the strobe pulse the DATA input is high the selected switch will turn on, and if the DATA input is low the switch is cleared. Thus it is necessary to strobe a switch on and off, as each switch has its own latch within the chip, and will remain on until it is either strobed off or the power supply to the chip is interrupted (when all switches will clear). Any number of switches (up to sixteen) can be operated at one time by strobing one on, then changing the address and strobing the next on, but in this design only four are ever operated simultaneously.



Extension Line Circuit.

## Input Cross Point Circuit (see Figures 4 & 5)

The connection between the calling and called extensions is made by one of the four connecting circuits (CCB's) provided. This means that up to four calls (using eight extensions) can be in progress at any one time. When a call is made it is first necessary for the ELC of the calling extension to be connected to one of the four CCBs, and this is done by the input crosspoint switches, ICs 11 to 14. Each of these four ICs have their X connections joined to the ELCs of the associated extensions, and the Y inputs are commoned with the other three ICs, and then connected to the four CCBs. Thus, by making one switch in any IC, an extension can be connected to one of the four CCBs. The address inputs of the crosspoint ICs are all connected in parallel, and the DATA inputs are all fed from the common pulse supply DA. Each one of the four ICs has a separate strobe input, and this input is used as a chip select.

In order to detect when a call is being made every one of the 64 crosspoint switches are made in turn, by applying a 6-bit binary count to the address and strobe lines of the crosspoint switch ICs. The four least significant bits of the address connect directly to the four address inputs of the 45100s, and the two most significant bits are connected to a decoder that enables each of the four ICs in turn.

When the high impedance 15V calling signal from the ELC is detected by one of the connecting circuits a strobe inhibit condition is initiated. This condition occurs every time a switch in the same Y row as the one in use is addressed. In the normal scan condition the pulse (SA) fed to the strobe inputs of the CP ICs is longer than the DATA pulse, so each switch is only on for the period of the DATA pulse. When a call is detected the strobe pulse is inhibited before the DATA pulse has changed back to low, and thus the switch remains made until the inhibit condition is removed at the end of a call.

The high impedance 15V is also fed from the ELCs via the data enable common, which only allows data pulses to be fed to the input CP switches when a new call is being made, thus preventing the CP switches from scanning continuously and interfering with working circuits.

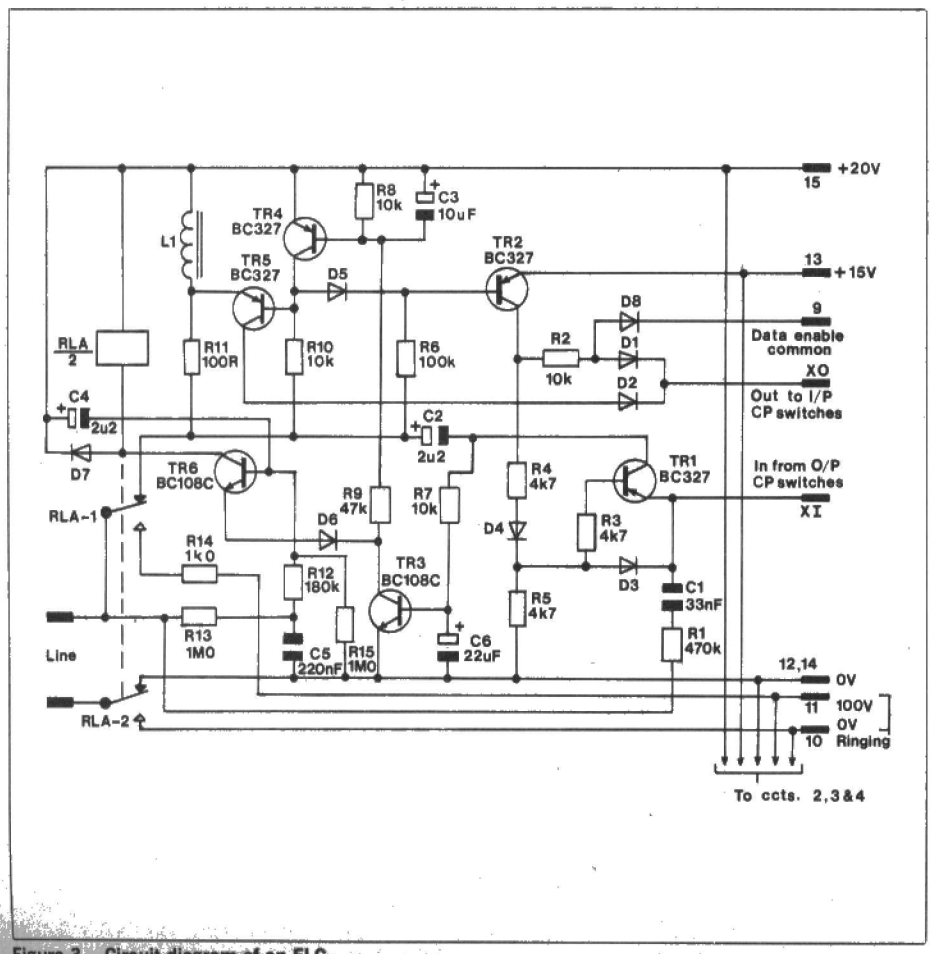
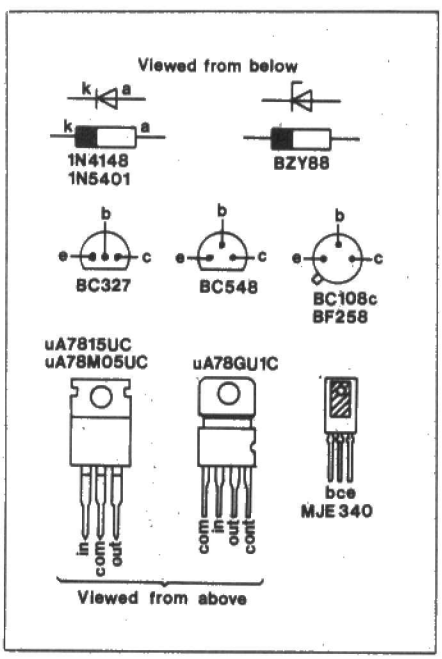



Figure 3. Circuit diagram of an ELC.



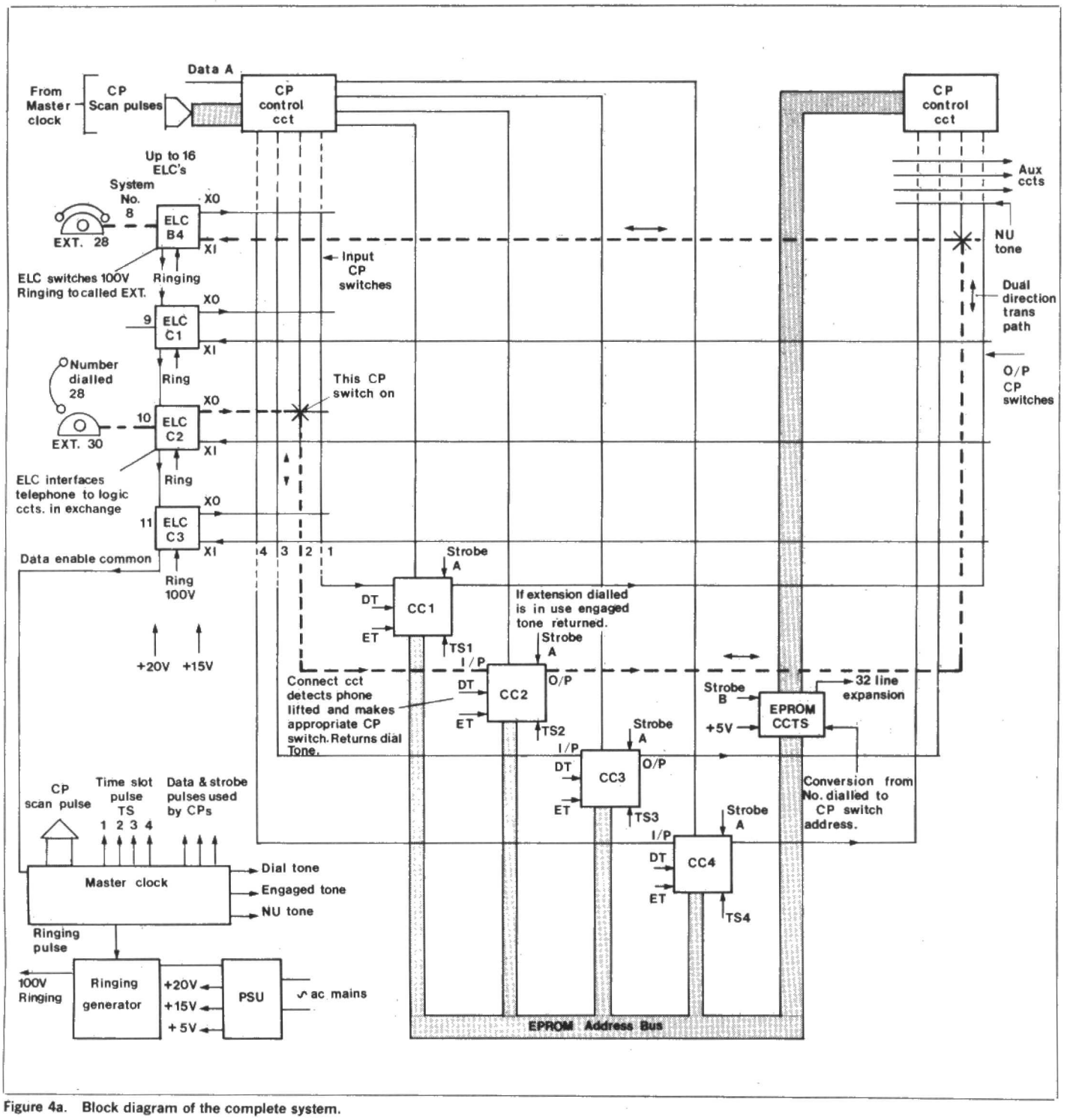



**Figure 4a. Block diagram of the complete system.**

# Connect Circuit Board (CCB) Figure 6

The main function of this part of the system is to receive and store the number dialled by the calling extension, and to apply this data to the EPROM (IC1 Figure 5) at the appropriate time. The CCB controls the input crosspoint switches, and also tests the called line to see if it is already in use, sending engaged tone back to the calling extension when necessary.

The incoming line, from one of the Y connections of the input crosspoint switch, is monitored by TR1 and TR2. TR1 is arranged to turn on only when an ELC is calling and has not yet been found by a CCB. The calling condition, when detected, causes the latch formed by IC3d & e to change state, and this latch controls the bilateral switch (IC2a), which terminates the incoming line with D3, thus causing the calling voltage to be reduced and preventing a second CCB from connecting to the calling ELC.

Strobe inhibit pulses, corresponding to the Y connection of the CCB in use, are gated by IC1d and are fed back to the CP control on the main board, preventing the CCB from switching off, as previously described.

When the latch changes state it causes a reset pulse to be generated. This pulse is used to clear all registers and counters of any previous data. IC8 is a status counter, and in its first position it enables dial pulses to be applied to the first binary counter (IC4b). Dial tone is connected to the calling extension via IC2c. Dialling causes the input to the CCB to be pulsed to 0V at the rate of 10 pulses per second, the number of pulses depending on the number dialled. The latch has a slow reset time so it remains on during dial pulses. IC3f forms a dialling present detector and this is used to step the status counter to its next position after the first digit has been dialled. When the status counter is in position 2 the dial pulses are fed to the second binary counter (IC4a), and thus both digits dialled are stored by the two counters. After the second digit is dialled the status counter steps to its third position, which connects the call, and tests to see if the called line is already in use.

The call is connected to the required extension by a second set of CP

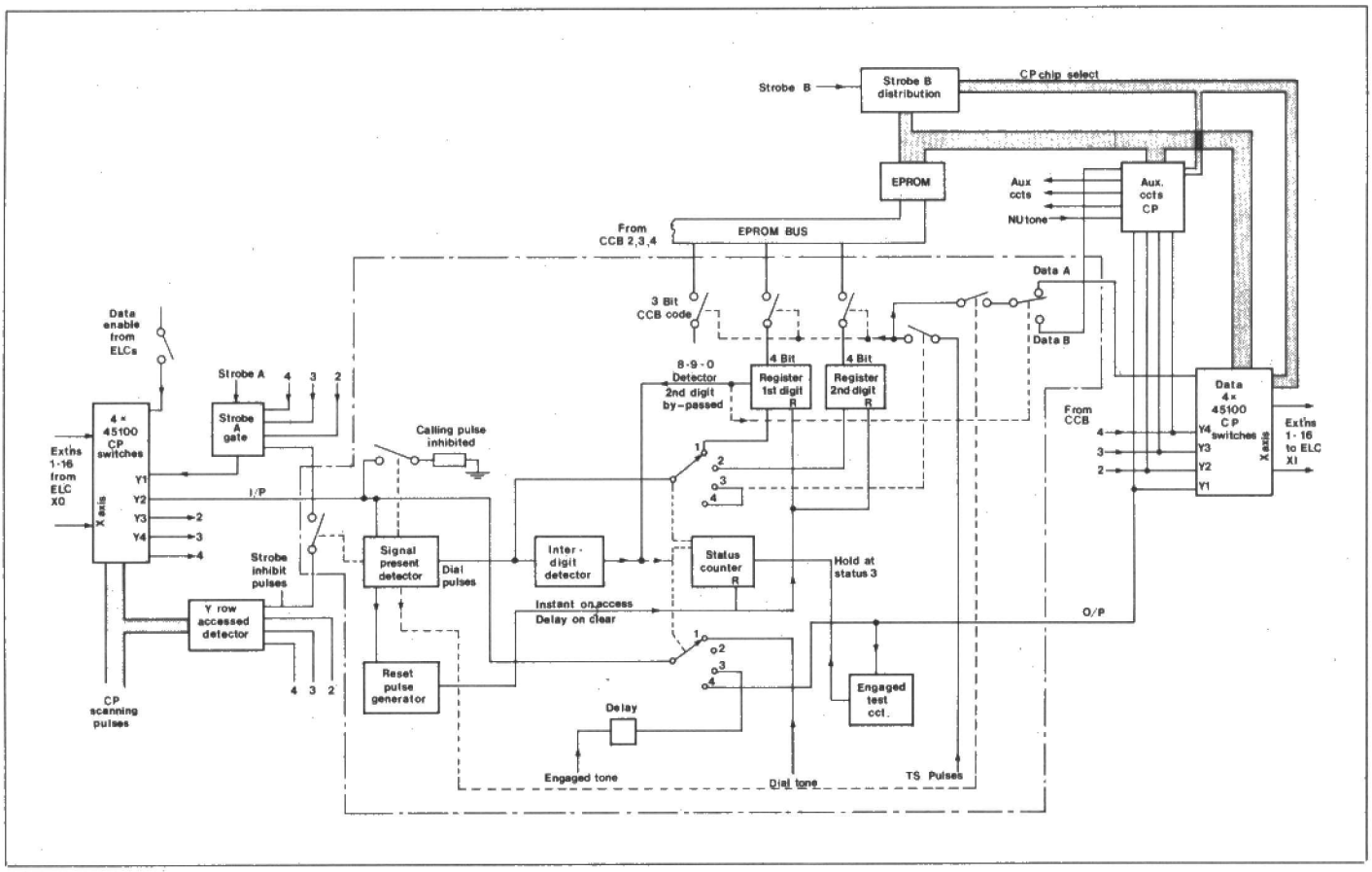



**Figure 4b. Block diagram of a CCB.**

switches (IC7 to 10), and these are controlled by data fed from the EPROM, which converts the data held in the binary counters of the CCB to the address needed to make the required CP switch. As there are up to eight CCBs in the system, each one is connected to the EPROM for only a short period (called a time slot) controlled by one of the eight TS pulses.

The status counter in position three enables the associated TS pulse to open the gates IC5 and IC6, and to apply the data in the counters, as well as a code indicating the CCB, to the EPROM address bus. The TS pulse is also used as a strobe inhibit and data pulse for the output CP switches. This is directly under the control of the incoming line condition to the CCB.

The required output CP switch is now made, and connected to the detector formed by TR4. When the circuit is already in use a potential will exist on the line, and this will cause TR4 to turn on, preventing the status counter from stepping to its final position and also connecting engaged tone back to the calling extension via IC2d. If no potential is detected by TR4 the status counter is allowed to step to its fourth position after a short delay, and this connects the line through from the input to the output of the CCB via IC2b.

## Auxiliary Circuits

(Figure 5)

Auxiliary circuits may be connected to this exchange, and these are obtained by dialling a single digit, i.e. 8, 9 or 0. When any of these numbers are dialled, the fourth binary bit of the first digit counter goes high, and this causes the status counter to be stepped on twice, thus bypassing the second counter. An additional CP switch (IC6) is used to connect the auxiliary circuits, and in order to access this the data pulse to the output CP switches is inhibited, and a data pulse is fed to the auxiliary CP switch instead.

## EPROM and Output Crosspoint Circuit

The output CP switches are connected in a similar manner to the input switches, with their X axis connected to the inputs of the ELCs, and their Y axis commoned between all chips, and connected to the four CCBs. When a call is made an address appears on the EPROM bus, at the same time a data pulse is fed to all the output CP switches via the data common. The EPROM translates the dialled code to the 8-bit address required to make the appropriate CP switch. Four bits are connected to the address inputs of the CP switches, two bits are fed to a decoder which forms a chip select, controlling a strobe pulse that is fed to any one IC at a time. The remaining two bits are used for system expansion.

The DATA pulse in this case is longer than the strobe pulse, so when both are present the CP switch addressed will be turned on and remain on during the period when other switches are being addressed.

When a call is terminated the DATA pulse stops immediately, but there is a delay before the STROBE and ADDRESS are cleared, this causes the selected switch to turn off.

## Number Unobtainable Tone (NU)

The unused outlets from the output CP switches are strapped to the NU tone supply, so when one of these numbers is dialled NU tone is fed back to the calling extension. If the number dialled is one not used by the system the EPROM causes the call to be connected to the NU tone supply via the fourth part of the auxiliary circuit CP switch.

## Master Clock

(Figure 5)

All pulses and tones used by the system are produced by the master clock circuit (Figure 5), controlled by an oscillator running at about 500Hz formed by IC15a and its surrounding circuitry. The mark/space ratio of the oscillator is set to give the correct pulse timing for the various strobe and data inputs of the CP switches. The DATA pulse for the input CP switches is fed from the oscillator through an inverter, and this signal is also used to clock the octal counter (IC16). The eight consecutive output pulses from IC16 are used as the TS pulses, and one is fed to each CCB. The output pulse from the oscillator is delayed by the monostable (IC15b), and this signal is used as STROBE A, and when inverted produces STROBE B output. The oscillator also feeds the two binary counters (ICs 17 and 18), whose first six outputs are used to scan the input CP switches, and the remaining outputs control the timing of the engaged and ringing

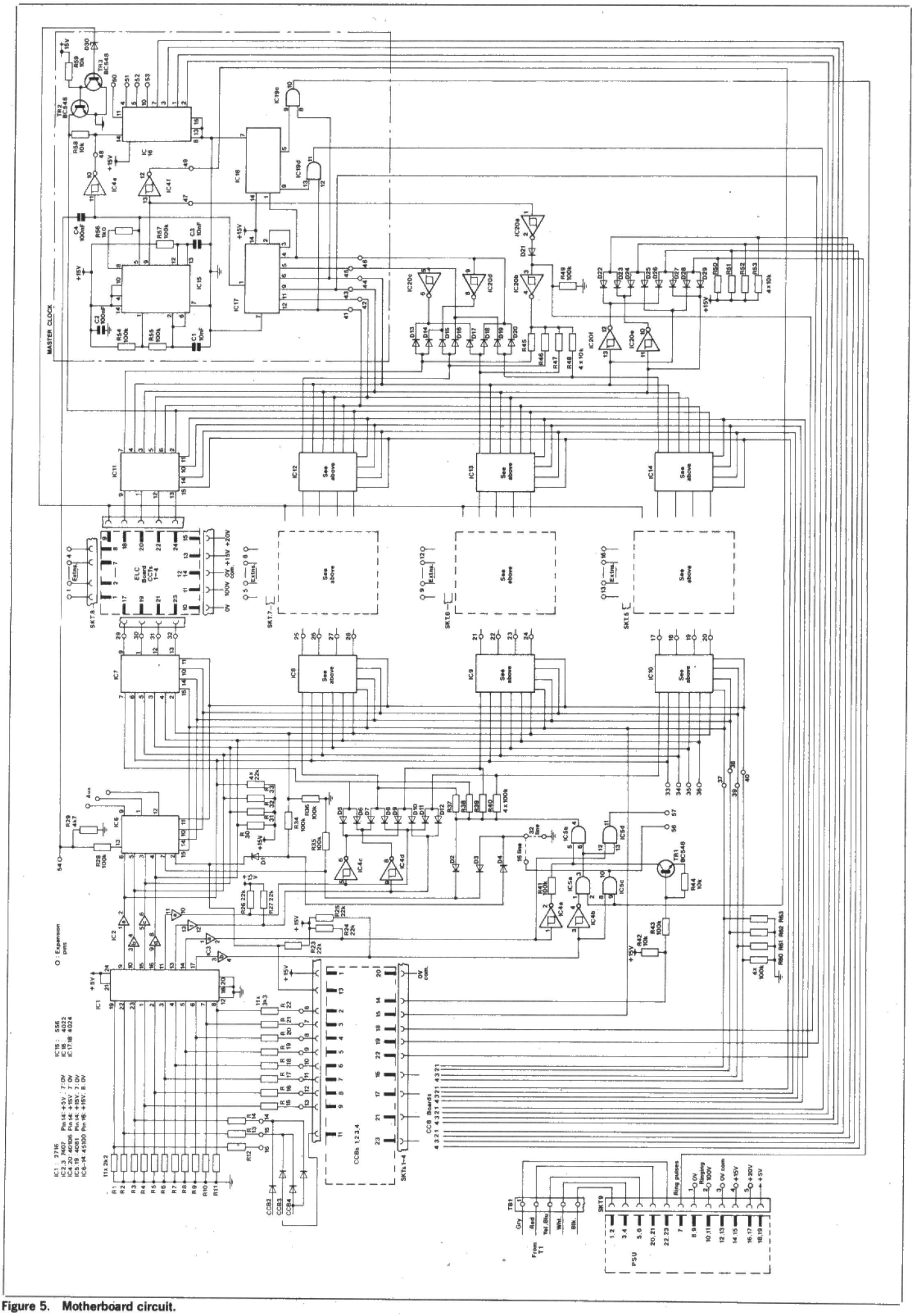



**Figure 5. Motherboard circuit.**

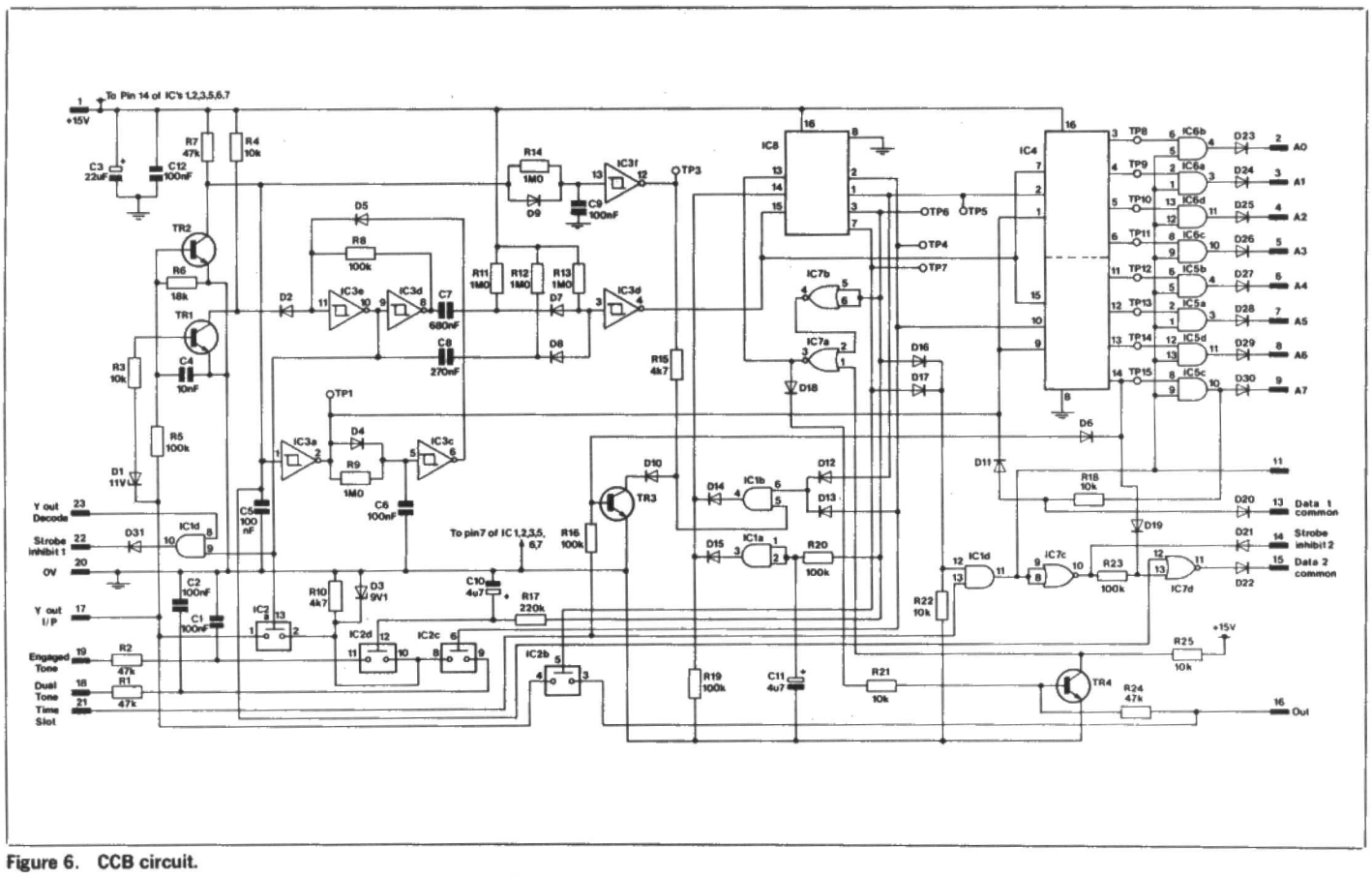


**Figure 6. CCB circuit.**

signals. The actual tones are produced by using various outputs from the binary counters, which are filtered on the individual CCBs.

The relationship between the STROBE, DATA, SCAN and TS pulses are shown in Figure 8.

## Power Supplies

(Figure 9)

AC mains is fed to the transformer T1, which has two secondary windings. The low voltage winding is rectified by D1 and D2 and fed to the three regulators. IC1 is set to give an output of about 20V, which is fed to the ELC units to provide the line current for the extensions. IC2 is a fixed 15V regulator, and is used to supply all the logic and switching circuits. The EPROM requires TTL voltage, and this is provided by IC3, which is fed from the 15V line. The ADDRESS inputs to the EPROM are reduced to the required 5V by potential divider circuits, while the DATA outputs are converted back to 15V logic levels by the open collector non-inverting buffers IC2 and IC3 on Figure 5. An AC supply of about 100V at 16Hz is required to ring the telephone bell, and the signal needed to produce this is generated by the master clock. The ringing signal is interrupted approximately every 4 seconds, and during this break the ringing voltage must remain high, in order to hold the relays operated in the ELCs until the call has been answered. The required 100V square wave is produced by alter-nately turning TR1 and TR2 on, thus switching the ringing supply output between 0V and 100V. The ringing supply has its own 0V line, and this is fed to the ELCs independently of normal 0V path. This is to prevent ringing currents inducing interference in working circuits.

| System Extension Number | Number Dialled | System Extension Number | Number Dialled |
|---|---|---|---|
| 1 | 21 | 19 | 39 |
| 2 | 22 | 20 | 30 |
| 3 | 23 | 21 | 41 |
| 4 | 24 | 22 | 42 |
| 5 | 25 | 23 | 43 |
| 6 | 26 | 24 | 44 |
| 7 | 27 | 25 | 45 |
| 8 | 28 | 26 | 46 |
| 9 | 29 | 27 | 47 |
| 10 | 20 | 28 | 48 |
| 11 | 31 | 29 | 49 |
| 12 | 32 | 30 | 40 |
| 13 | 33 | 31 | 51 |
| 14 | 34 | 32 | 52 |
| 15 | 35 | Aux 1 | 8 |
| 16 | 36 | Aux 2 | 9 |
| 17 | 37 | Aux 3 | 0 |
| 18 | 38 | | |

**Figure 7. Number conversion table.**

## Putting the System Together

The exchange is built on a mother-board, which contains the Master Clock and all the common circuits required for a complete system. The ELCs and CCBs are plug-in modules, to enable the system to be built up as required, in multiples of four extensions.

The ELC kit contains not only the components for the ELC boards, but also the CP switch required to cater for up to 4 lines. Each CCB will enable one call to take place at a time (between 2 extensions), and from one to four CCBs may be installed, depending on the amount of extensions required, and the number of calls to be made simultaneously.

Construct all boards referring to the appropriate parts list and PCB legend. IC holders need only be inserted for the CP switches (ICs 6 to 14) and the EPROM. The output CP ICs 6 to 10 are provided with the mother board kit, and should all be inserted when building the mother board, but the input CP switch ICs are provided with the ELC kit, and are inserted as necessary. Observe the usual CMOS precautions when handling these ICs (see relevant page of our catalogue), and always turn off the power when making any circuit changes or additions.

It should be noted that the voltage required to ring the telephone bells can give an unpleasant shock should it be touched, so it is always advisable to switch off the mains supply before working on the exchange, extension, or a line to an extension.

## Testing

Insert the PSU into the motherboard and connect mains supply. The following readings should be obtained relative to 0V (TP5).

| PSU test points | Voltages |
|---|---|
| 1 | +18.5V to +22V |
| 2 | +14V to +16V |
| 3 | +4.8V to +5.2V |
| 4 | 120V to 160V, falling to approx. 80V every 2-4 seconds. |

Switch off the mains, and insert one ELC board in position A, and one CCB in any position. Connect two telephones to 1 and 4 on the block marked extensions 1 to 4, and switch the mains on. Lift the handset on the telephone con-

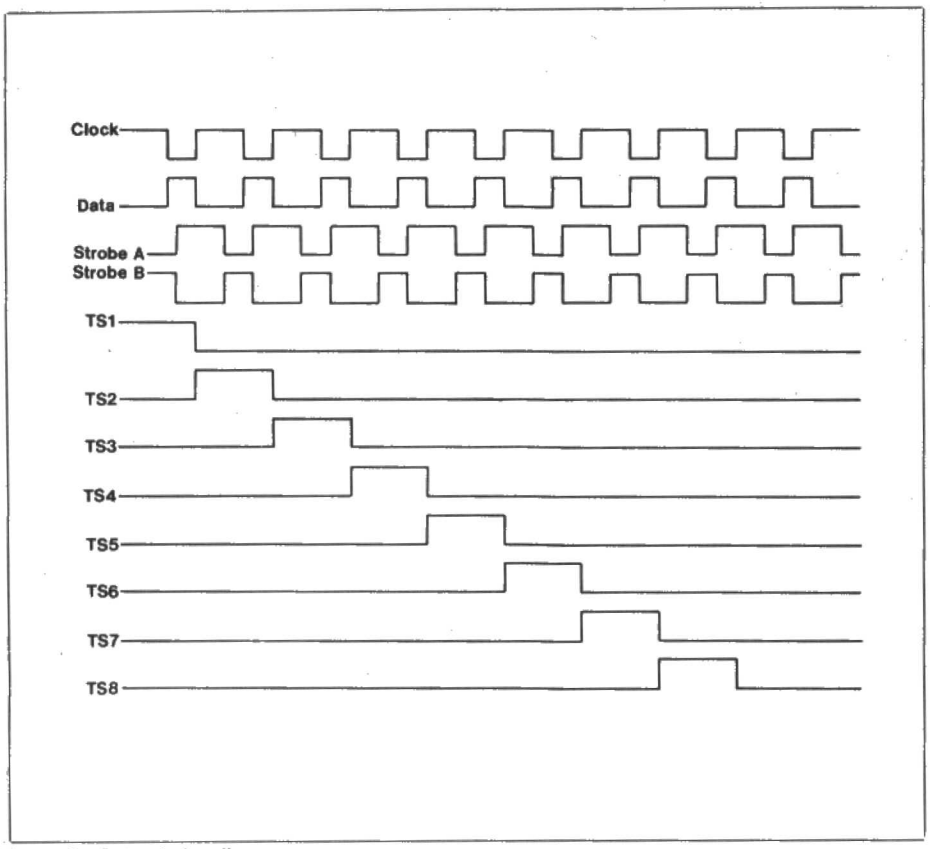
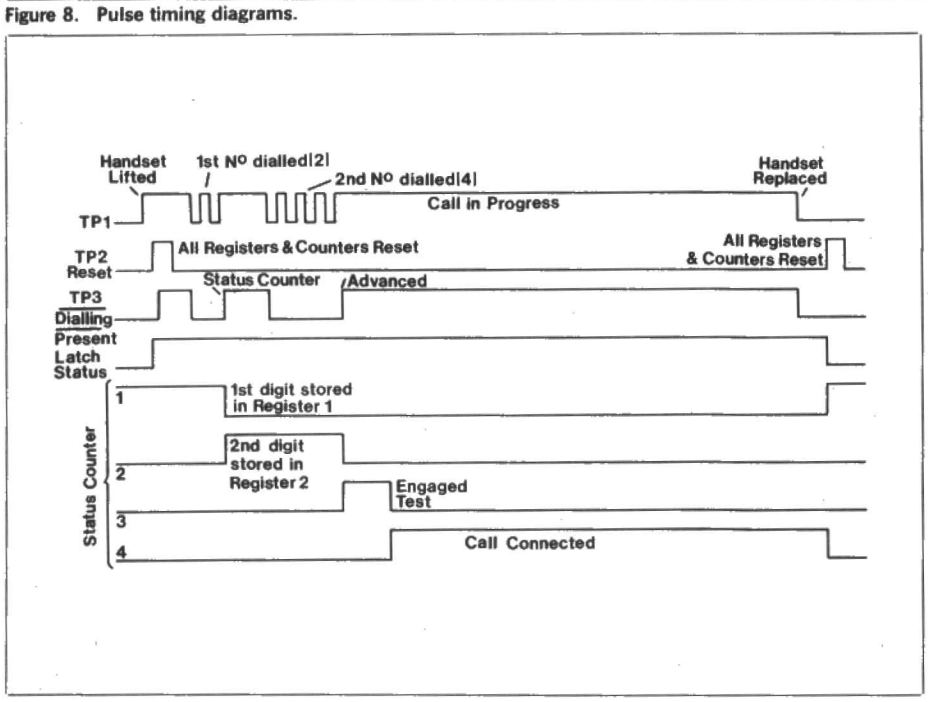



Figure 8. Pulse timing diagrams.




nected to 1 and dial tone should be heard as the CCB picks up the calling circuit. Lift the handset of the second telephone before replacing that of the first, this time NO dial tone should be heard. Replace the second telephone handset, and dial 24 on the first. The bell should now ring, and when the handset is lifted it should be possible to communicate in both directions between the two extensions. Now repeat this test, but this time with the handset of the second telephone raised. Engaged tone should now be heard. Repeat the above tests with another CCB and ELC until all the boards have been tested, remembering to switch the power off whilst changing boards.

All the boards can now be inserted, and the system should be fully working. In order to provide NU tone on spare extensions the appropriate SL pins should be linked to the NU pin (these are located between the ELC connectors on the mother board).

## Numbering Scheme

The relationship between the extension system number, and the number dialled to obtain that extension are shown in Figure 7. The auxiliary circuits are selected by dialling 8, 9, or 0, and connections to these will be described in a later article.

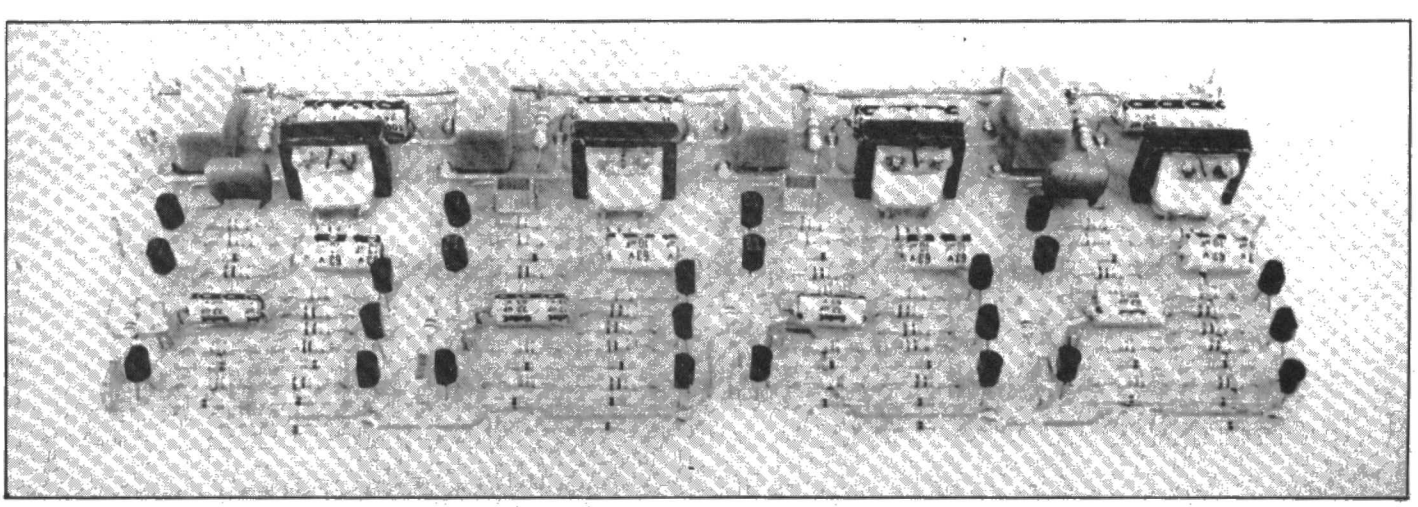
## Expansion

System expansion, up to the full 32 lines, is accomplished by connecting a second mother board to the pins provided for this purpose on the left side of the main mother board. The expansion board has positions for a further four ELC and CCB boards, but has no master clock or EPROM, as the main board provides these.

The expansion board, interfacing to external lines, and a possible switchboard will be described in later articles.

## Installing the System

The exchange should be placed in a convenient position near a mains supply, and at a point where wiring to the extensions will be as easy as possible. The connection to each extension may be made with any two-core cable, but Maplin supply British Telecom type four-core cable specially for



## PARTS LIST FOR DIGI-TEL CONNECT CIRCUIT

Resistors — All ⅓W 5% carbon unless specified

| | | | |
|---|---|---|---|
| R1,2,7,24 | 47k | 4 off | (M47K) |
| R3,4,18,21,22,25 | 10k | 6 off | (M10K) |
| R5,8,16,19,20,23 | 100k | 6 off | (M100K) |
| R6 | 18k | 1 off | (M18K) |
| R9,11,12,13,14 | 1M0 | 5 off | (M1M0) |
| R10,15 | 4k7 | 2 off | (M4K7) |
| R17 | 220k | 1 off | (M220K) |
| **Capacitors** | | | |
| C1,2,12 | 100nF Polyester | 3 off | (BX76H) |
| C3 | 22uF 63V PC elect | 1 off | (FF07H) |
| C4 | 10nF polycarbonate | 1 off | (WW29G) |
| C5,6,9 | 100nF polycarbonate | 3 off | (WW41U) |
| C7 | 680nF polycarbonate | 1 off | (WW51F) |
| C8 | 270nF polycarbonate | 1 off | (WW46A) |
| C10,11 | 4u7 63V PC elect | 2 off | (FF03D) |
| **Semiconductors** | | | |
| D1 | BZY88C11 | 1 off | (QH15R) |
| D2,4-31 | 1N4148 | 29 off | (QL80B) |
| D3 | BZY88C9V1 | 1 off | (QH13P) |
| TR1-4 | BC108C | 4 off | (QB32K) |
| IC1,5,6 | 4081BE | 3 off | (QW48C) |
| IC2 | 40066BE | 1 off | (QX23A) |
| IC3 | 40106BE | 1 off | (QW64U) |
| IC4 | 4520BE | 1 off | (QX33L) |
| IC7 | 4001BE | 1 off | (QX01B) |
| IC8 | 4022BE | 1 off | (QW19V) |
| **Miscellaneous** | | | |
| | Veropin 2141 | 1 Pkt | (FL21X) |
| | PC Board | 1 off | (GB05F) |

A complete kit of all parts listed above is available.
**Order As LW81C (Digi-Tel Connect Kit). Price £9.95**

## PARTS LIST FOR DIGI-TEL EXTENSION LINE CIRCUIT

Resistors — All ⅓W 5% carbon unless specified

| | | | |
|---|---|---|---|
| R1 | 470k | 1 off | (M470K) |
| R2,7,8,10 | 10k | 4 off | (M10K) |
| R3,4,5 | 4k7 | 3 off | (M4K7) |
| R6 | 100K | 1 off | (M100K) |
| R9 | 47K | 1 off | (M47K) |
| R11 | 100R (½w) | 1 off | (S100R) |
| R12 | 180k | 1 off | (M180K) |
| R13,15 | 1M0 | 2 off | (M1M0) |
| R14 | 1k0 (½w) | 1 off | (S1K0) |
| **Capacitors** | | | |
| C1 | 33nF polycarbonate | 1 off | (WW35Q) |
| C2,4 | 2u2 63V PC elect | 2 off | (FF02C) |
| C3 | 10uF 63V PC elect | 1 off | (FF05F) |
| C5 | 220nF polycarbonate | 1 off | (WW45Y) |
| C6 | 22uF 63V PC elect | 1 off | (FF07H) |
| **Semiconductors** | | | |
| D1-8 incl. | 1N4148 | 8 off | (QL80B) |
| TR1,2,4,5 | BC327 | 4 off | (QB66W) |
| TR3,6 | BC108C | 2 off | (QB32K) |
| **Miscellaneous** | | | |
| L1 | Choke 10H | 1 off | (HW27E) |
| RLA | Relay DPDT | 1 off | (YX95D) |

* All above items to be multiplied by 4 for use on 1 PCB.

| | | |
|---|---|---|
| PC board | 1 off | (GB04E) |
| Track Pin | 1 Pkt | (FL82D) |
| Veropin 2141 | 1 Pkt | (FL21X) |

A complete kit for 4 circuits on 1 pcb is available.
**Order As LW80B (Digi-Tel ELC Kit). Price £24.95**

## PARTS LIST FOR DIGI-TEL POWER SUPPLY

Resistors — All ¼W 5% carbon unless specified

| | | | |
|---|---|---|---|
| R1 | 8k2 | 1 off | (S8K2) |
| R2 | 13k | 1 off | (S13K) |
| R3 | 4k3 | 1 off | (S4K3) |
| R4,R7,10 | 1k0 | 3 off | (S1K0) |
| R5 | 2k7 | 1 off | (S2K7) |
| R6 | 4k7 | 1 off | (S4K7) |
| R8 | 3k3 | 1 off | (S3K3) |
| R9 | 10k | 1 off | (S10K) |
| **Capacitors** | | | |
| C1 | 100uF, 250V axial electrolytic | 1 off | (FB53H) |
| C2 | 2200uF 40V axial electrolytic | 1 off | (FB91Y) |
| C3,4,5 | 100nF polyester | 3 off | (BX76H) |
| **Semiconductors** | | | |
| BR1 | S04 | 1 off | (QL10L) |
| D1,2 | IN5401 | 2 off | (QL82D) |
| TR1,2 | MJE340 | 2 off | (QH54J) |
| TR3 | BF258 | 1 off | (QF17T) |
| TR4 | BC548 | 1 off | (QB73Q) |
| IC1 | uA 78GU1C | 1 off | (WQ79L) |
| IC2 | uA 7815UC | 1 off | (QL33L) |
| IC3 | uA 78M05UC | 1 off | (QL28F) |
| **Miscellaneous** | | | |
| | PC board | 1 off | (GB07H) |
| | Heatsink 4Y | 1 off | (FL41U) |
| | Bolt 6BA ½" | 2 off | (BF06G) |
| | Nut 6BA | 2 off | (BF18U) |
| | Washer 6BA | 2 off | (BF22Y) |

## PARTS LIST FOR DIGI-TEL MOTHERBOARD

Resistors — All ⅓W 5% carbon unless specified

| | | | |
|---|---|---|---|
| R1-11 | 2k2 | 11 off | (M2K2) |
| R12-22 | 3k3 | 11 off | (M3K3) |
| R23-27,R30-33, R28,34-36,41,43, 49,54,55,57, 60-63 | 22k | 9 off | (M22K) |
| R29 | 100k | 14 off | (M100K) |
| R37-40,42,44-48, 50-53,58,59 | 4k7 | 1 off | (M4K7) |
| R56 | 10k | 16 off | (M10K) |
| | 1k0 | 1 off | (M1K0) |
| **Capacitors** | | | |
| C1,3 | 10nF polycarbonate | 2 off | (WW29G) |
| C2,4 | 100nF polyester | 2 off | (BX76H) |
| **Semiconductors** | | | |
| D1-29,31-34 | IN4148 | 33 off | (QL80B) |
| D30 | BZY88C12 | 1 off | (QH16S) |
| TR1-3 | BC548 | 3 off | (QB73Q) |
| IC1 | 2716/M4 | 1 off | (QY25C) |
| IC2,3 | 7407 | 2 off | (QX76H) |
| IC4,20 | 40106 | 2 off | (QW64U) |
| IC5,19 | 4081 | 2 off | (QW48C) |
| IC6-14 | 45100 | 9 off | (QQ51F) |
| IC15 | 556 | 1 off | (QH67X) |
| IC16 | 4022 | 1 off | (QW19V) |
| IC17,18 | 4024 | 1 off | (QX13P) |
| **Miscellaneous** | | | |
| | PC board | 1 off | (GB06G) |
| | 8way PC terminal | 5 off | (RK38R) |
| | Edge conn. 124 | 9 off | (FL85G) |
| | Edge conn. foot G | 9 off | (FL91Y) |
| | Edge conn. foot H | 9 off | (FL92A) |
| | Dil socket 16 pin | 9 off | (BL19V) |
| | Dil socket 24 pin | 1 off | (BL20W) |
| | Track pin | 7 Pkts | (FL82D) |
| | Veropin 2141 | 1 Pkt | (FL21X) |
| | Bolt 6BAx½" | 18 off | (BF06G) |
| | Nut 6BA | 18 off | (BF18U) |
| | Washer 6BA | 18 off | (BF22Y) |

## DIGI-TEL MISCELLANEOUS PARTS LIST

| | | |
|---|---|---|
| Toroidal transformer 24/100V | 1 off | (YK33L) |
| SA fuseholder 20 | 1 off | (RX96E) |
| Fuse A/S 2A | 1 off | (WR20W) |
| P.B. telephone | Set of 4 | (XG19V) |
| P.B. telephone | 1 off | (XG18U) |
| Cable (4 wire phone cable) | As req | (XR66W) |
| Terminal block 5A | 1 off | (HF01B) |
| Tag 2BA | 1 off | (BF27E) |
| Mains lead | As req | (XR04E) |
| Wire 3202 white | 2M | (XR37S) |

See next page for details of Digi-Tel Main Kit.

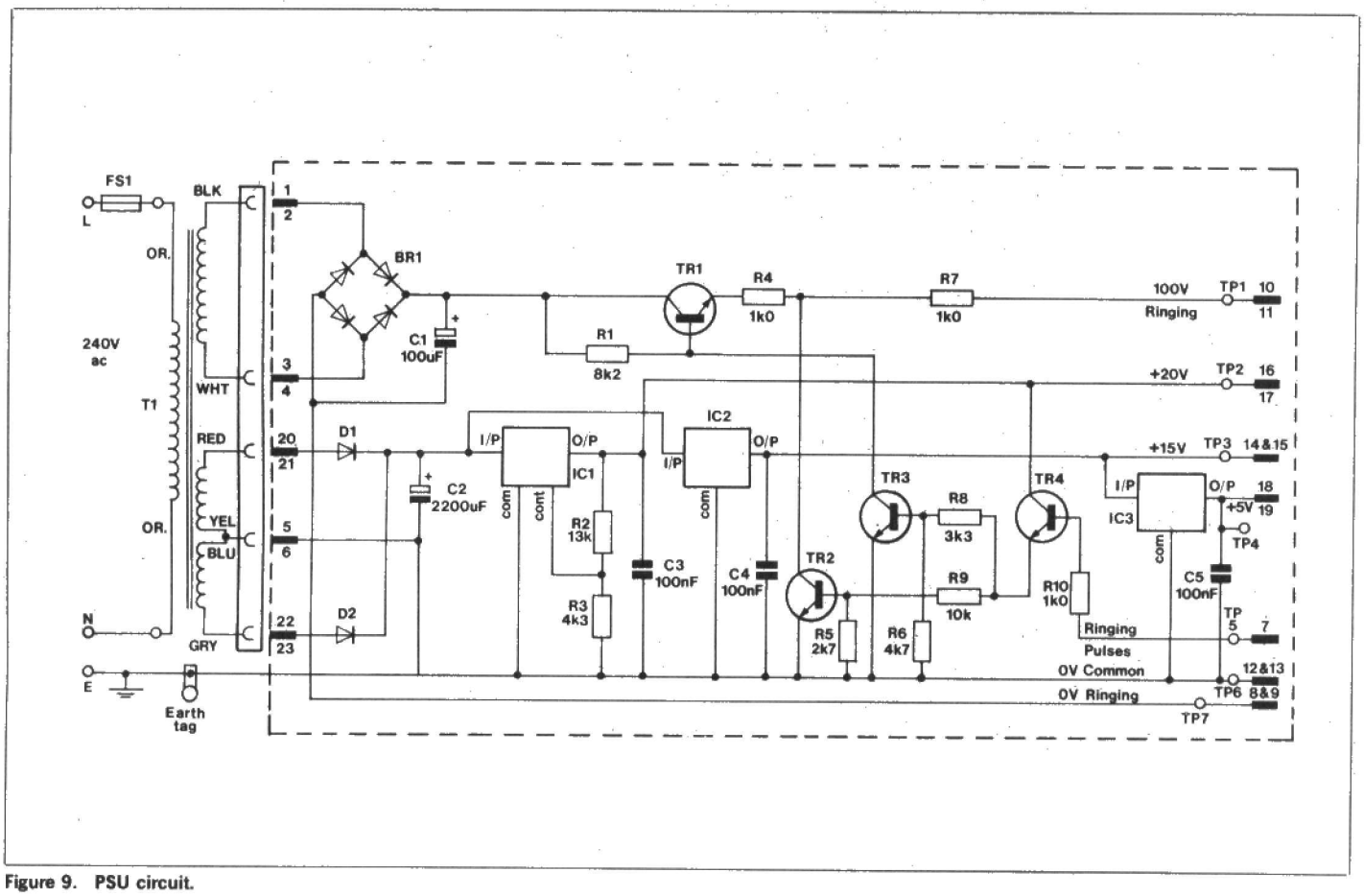



Figure 9. PSU circuit.

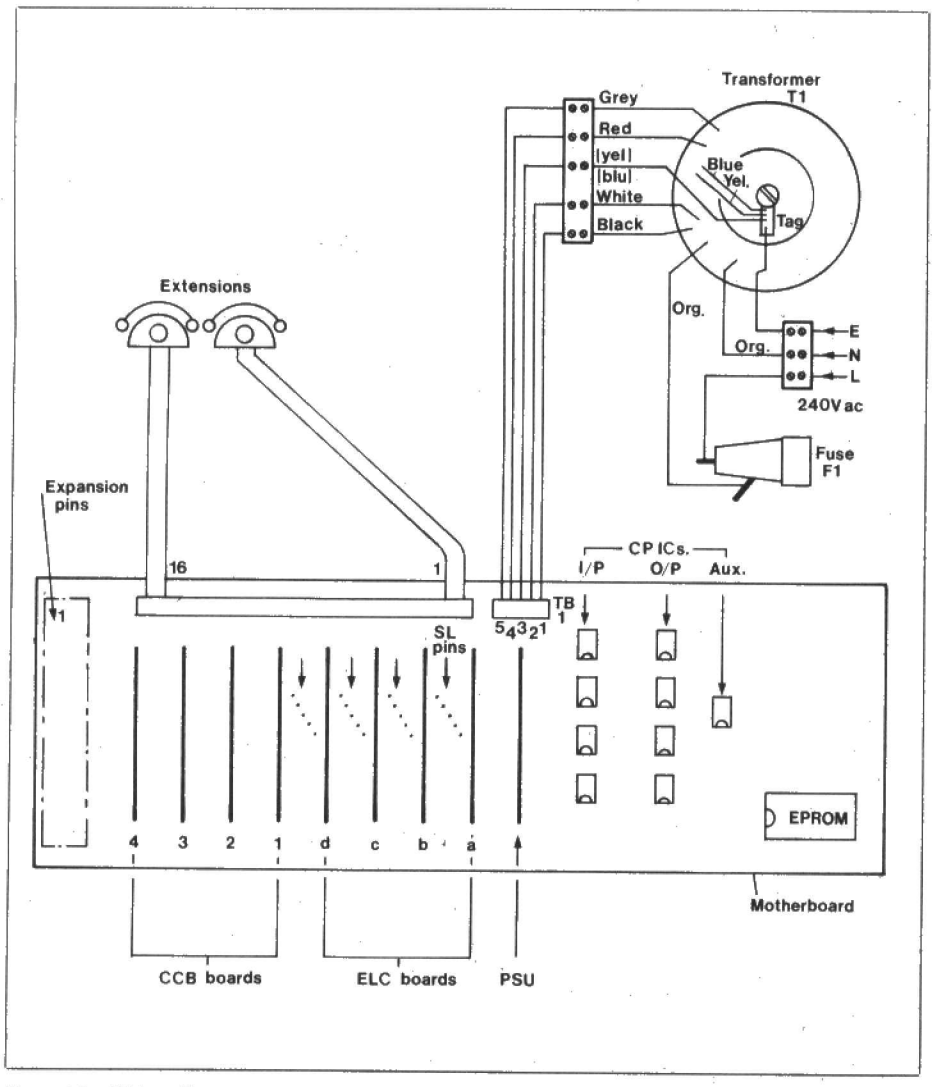



Figure 10. Wiring diagram.

this purpose (XR66W). This cable may, of course, be used to feed two extensions, one on each pair.

No case is shown for the exchange, but this may be simply constructed as a wooden box, with the mother board mounted either vertically or horizontally. If the mother board is mounted vertically the plug-in cards may need some support on their lower edges, and this can be accomplished by using a piece of wood with shallow slots cut in it for the cards to slide along. Adequate ventilation should be provided, particularly near the PSU card and transformer. Provision should be made in the case for system expansion, allowing room for a second mother board of the same dimensions as the first, and mounting adjoining the pins provided.

## DIGI-TEL MAIN KIT

A complete kit is available of all the parts shown for the Power Supply, Mother Board and Miscellaneous except telephones.

**Order As LW82D (Digi-Tel Main Kit). Price £67.50**

*Please note that kits for Digi-Tel will not be available until late September and telephones will not be available until late October. For prices of telephones see page 47.*

# WORKING WITH OP-AMPS

by Graham Dixey C.Eng., M.I.E.R.E.

## Part 3

Op-amps used in a switching mode are essentially generators of square-waves. Control of repetition frequency, pulse length, mark/space ratio and delay time are possible. What precisely is controlled depends upon the exact nature of the circuit. Thus, astable circuits generate continuous square-waves, variable in frequency and mark/space ratio; monostable circuits produce pulses of defined length or time delays, while bistables may be thought of as temporary stores of binary data. Thus it is that the op-amp, usually considered as a linear device, crosses right over into the digital field.

These basic 'building blocks' were covered in Part Two of this series. In Part One, one of the circuits discussed was the 'integrator' which, it may be remembered, produced a linear ramp as a result of a step of voltage at its input. Therefore, if the latter circuit were fed with a train of square-waves, its response would be to generate a continuous triangular waveform. The point is that the ability to convert from one type of waveform to another gives rise to the idea of a circuit that is capable of producing several quite different but 'frequency related' waveforms simultaneously — in other words, a 'function generator'. This 'first stage development' is shown in Figure 1 in the form of the 'hysteresis oscillator'. Two outputs, square-wave and triangle, are produced by the technique mentioned above.

### The Hysteresis Oscillator

To understand how the circuit works, assume that the output of IC1 is initially in positive saturation i.e. at some voltage +V volts. Then, a current given by V/R3 will flow to charge the feedback capacitor C1 of the integrator IC2. As a result, the output of IC2 will fall linearly and continue to do so until it reaches -V/2 volts; this is output B, the triangle waveform. At this instant, the output of IC1 is forced to switch from positive saturation to negative saturation because of the fed back voltage at the junction of R1 and R4. What then follows is similar to what has been described except that the output of IC2 now 'rises' linearly until it reaches the next 'switch-on' point at +V/2 volts, from which the whole cycle repeats again, and so on indefinitely.

Thus, output B 'runs' alternately between the amplitude limits of +V/2 and -V/2 volts while, simultaneously, output A switches between the amplitude limits of +V and -V volts. The periodic time of either excursion is R3.C1 seconds so that the repetition frequency of the output is equal to 1/(2.R3.C1) Hz — R3 in ohms and C1 in Farads.

To take an example, if a frequency of 100Hz is required and a 100nF capacitor is available, the required value of resistor is found by substituting these values into the formula which, after transposing and evaluating, gives R3 as 50k. An obvious way of adjusting the frequency to exactly 100Hz is to use, for R3, a fixed 47k resistor in series with a 5k pre-set potentiometer. This formula for the frequency is based upon the circuit values given in Figure 1. Changing the ratio

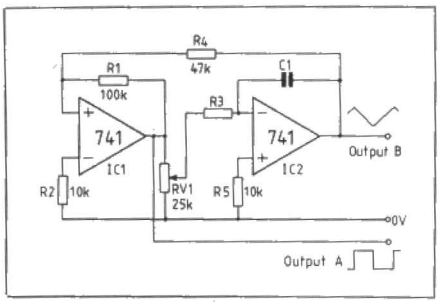



**Figure 1. The hysteresis oscillator.**

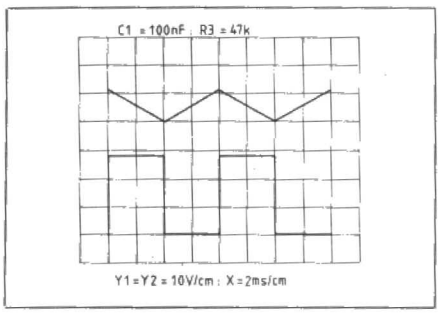



**Figure 2. Waveforms of the hysteresis oscillator.**

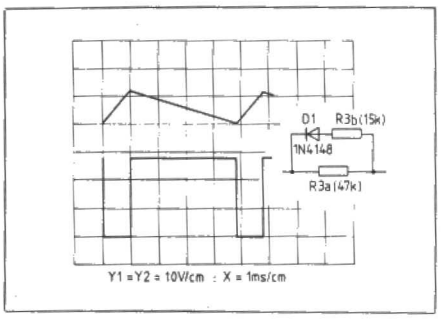



**Figure 3. Waveforms of an asymmetric circuit.**

R4/R1 moves the switch-on point in time, which then controls the amplitude of output B and obviously changes the frequency of operation. The limiting factor is that the ratio of R4/R1 must be unity or less, otherwise the circuit will stop oscillating. The frequency also depends upon the amplitude of the square-wave fed to IC2 because, as was explained in Part Two, the slope of the wave out of an integrator depends not only on the integrator time constant, but also on the magnitude of the step input. So, by feeding IC2, not from the full output of IC1 but from a portion of it (up to the maximum) derived from a potentiometer, continuously variable control of frequency is available over a reasonably wide range. Using the values given in Figure 1, the variation of frequency available using RV1 was from about 6.25Hz to 125Hz. The waveforms obtained at both outputs at 125Hz are shown in Figure 2.

Sometimes a mark/space ratio other than unity is required; to do this it is necessary to introduce some asymmetry into the circuit. To achieve this objective means finding a frequency-dependent component and making it change its value automatically on alternate half-cycles. This implies the use of a diode to provide two unequal 'polarity-conscious' paths. The obvious choice of component is R3 and the modification is shown in Figure 3 together with sample waveforms obtained. On the half-cycles when the output from IC1 is positive-going, D1 is non-conducting and R3 equals R3a i.e. equals 47k. But, on the negative half-cycles, D1 conducts and puts R3a and R3b in parallel — an effective value of R3 of 11.4k. The mark/space ratio should then be 47/11.4, that is slightly over 4:1. This is verified by the waveforms of Figure 3, which shows that the actual mark/space ratio obtained was 3.8:1, within the tolerance of the resistors used (10%).

### Sine-shaping Circuit

The hysteresis oscillator, which produces two different but related waveforms, has been referred to as the 'first stage development' of a function generator. This is justifiable if it is accepted that such a circuit cannot really be said to be complete unless there is also a sine-wave output. There are various ways of adding this facility but one of interest is the method of using an op-amp inverting amplifier with a sine-wave approximation network to develop the sinewave output from a triangle input. A number of diodes are used in the feedback path of the op-amp that conduct at different levels of the input, changing the gain and hence the slope of the output. The sinewave is thus represented by a succession of different slopes and quite a reasonable approximation is possible. The arrangement of the diodes and associated resistors is shown in Figure 4, together with a sketch of the principle involved.

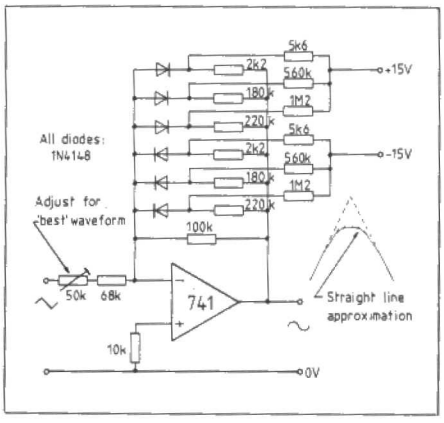



**Figure 4. Sine-shaping circuit.**

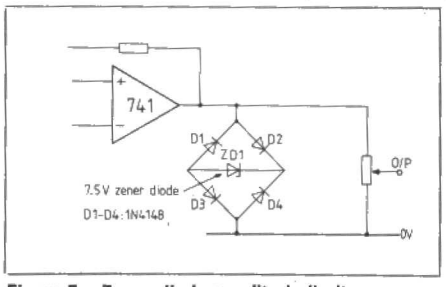



**Figure 5. Zener diode amplitude limiter.**

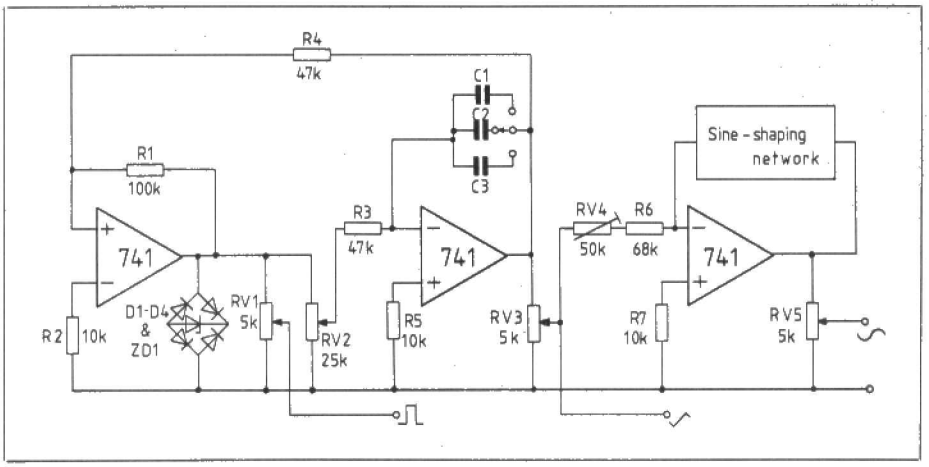



**Figure 6. Function generator.**

## Square-wave Clamping

The waveform of the square-wave generated by the circuit of Figure 1 is good at the low frequencies but, in the kHz region begins to show some 'sag'. An obvious way of getting over this is to clip off the peaks of the square-wave or, to describe the process more correctly, to clamp the square-wave to a predetermined level, well below that at which the sag is likely to occur. A zener diode will make an effective and consistent clamp and if just one diode is used, together with a diode bridge, as shown in Figure 5, the clamping action will be precisely symmetrical, the zener diode acting equally on both half-cycles of the square-waveform.

## A Function Generator

To make a function generator that is at all versatile, range-switching of frequency and control of amplitudes is desirable. The latter can most easily be provided by potentiometers at each output, and the former requirement can be met by switching the value of C1; fine control of frequency will be by use of the potentiometer between stages. A scheme incorporating all of the ideas discussed so far is shown in Figure 6. Most component values are shown but the values of C1, C2 and C3 are left to the experimenter to select for himself, sufficient information having now been given for him to be able to do this.

## An Alternative Approach

The method of generating three related functions just described was based upon the use of a square/triangle generator with the sinewave function being added on. But the versatility of the op-amp is such as to allow us to 'swap' the process around and start off with the sinewave. From this point, the sinewave can be 'squared off' (giving the square-wave output) and this waveform, in turn, integrated in an op-amp integrator to give the triangle output. What is then needed, as a starting point, is a sinewave oscillator of the RC type.

## The Twin-Tee Oscillator

The frequency-selective network that starts and maintains the oscillations in this circuit is a 'twin-tee' filter network. In Figure 7, the component values are based upon a resistance R and a capacitance C. The shunt resistance branch, nominally equal in value to R/2, is actually de-tuned slightly by a 2k5 pre-set. The phase-shift through the network is then 180° with some attenuation (dependent upon the degree of de-tuning). The op-amp has 180° of phase-shift as well between the inverting input and the output and very high gain. As a result, the 'loop phase shift' is

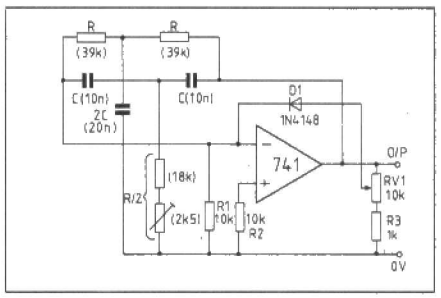



**Figure 7. Twin-tee oscillator.**

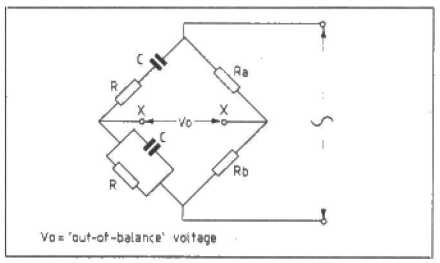



**Figure 8. The Wien bridge.**

360°, giving positive feedback and with the R/2 arm adjusted carefully, the circuit bursts into oscillation; the 2k5 pre-set should be carefully adjusted to give a sine-wave with minimum distortion. All of this happens at a unique frequency which equals $1/(2\pi R.C)$.

Even so, the degree of distortion may not be acceptable so a stabiliser can then be used that will give some improvement. A simple stabiliser, shown in Figure 7, consists of D1, R3 and RV1, the latter acting as an output control. The improvement in waveform with this simple modification is worthwhile, though there is some reduction in the maximum output. With 15V supplies, the unstabilised circuit can give 27V peak to peak output, which is reduced to about 8.5V peak to peak when the stabiliser is fitted, still a worthwhile output.

With the values of R, C, R/2 and 2C shown in brackets in Figure 7, the design frequency was 400Hz. Using 5% resistors and 10% capacitors, the measured frequency on test was 435Hz, which is within the allowable limits. Obviously the use of closer tolerance components would have given a result closer to the design figure.

To change the frequency of the twin-tee oscillator means changing the values of at least three components simultaneously (e.g. all three resistors in the filter network). This is not usually very practicable so this circuit is unlikely to be chosen except as a fixed frequency oscillator.

## The Wien Bridge Oscillator

This might justifiably be called the 'classic RC oscillator', since it is almost universally used to generate low-frequency sinewaves, especially where a wide frequency range is required. It is based on the properties of the Wien network, which is an RC combination that has zero phase-shift and a loss of 3:1 at a frequency equal to $1/(2\pi R.C.)$. This formula assumes that both resistors have the same value and also both capacitors are equal, which is usually the case. At first sight it might appear that all that is needed is an amplifier with a gain of 3 and zero phase-shift. However, it is better in practice to use a high-gain amplifier and include negative feedback to improve the stability of the circuit. This implies some sort of balance between the two types of feedback, positive and negative. This is achieved by adding two extra resistors to form a bridge, this being shown in Figure 8. It is these two resistors that provide the negative feedback, since they form a potential divider across the output and are connected at their junction to the inverting input of an op-amp in the final circuit. When this bridge is just 'off balance', a small voltage at the oscillatory frequency appears across X-X. It is this small voltage that is subject to the high gain of the op-amp to develop the output voltage.

A possible circuit is shown in Figure 9. One point that is to be noticed immediately is that the frequency is controlled by twin-gang potentiometers RV1/RV2 so that a resistance change from R1 to (R1 + RV1) is possible in the series arm, with an identical change taking place simultaneously in the parallel arm. Another feature of the circuit is that Ra consists of a potentiometer RV3 and two diodes, D1 and D2, back to back. The idea is to provide a non-linear element that will control the degree of out-of-balance of the bridge automatically to compensate for amplitude variations. RV3 is adjusted for the best waveform.

With the values shown in Figure 9 the frequency range obtained was from 220Hz to 1kHz, and the output level was about 1.25V peak to peak. Further ranges can be added by switching the capacitor values.

A more effective stabiliser uses a NTC thermistor, such as an R53, in place of the potentiometer/diodes network. However, these thermistors are extremely expensive and rarely justified except in a permanent design of some sophistication.

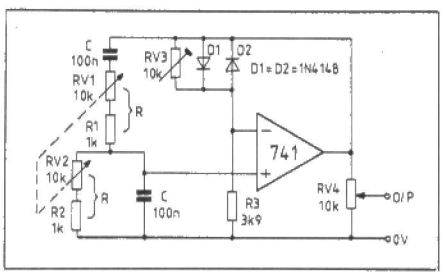



**Figure 9. The Wien bridge oscillator.**

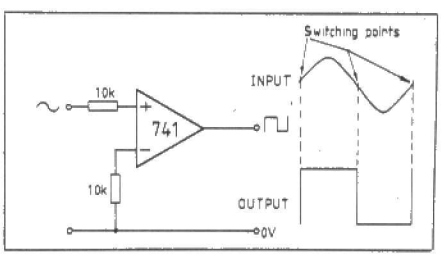
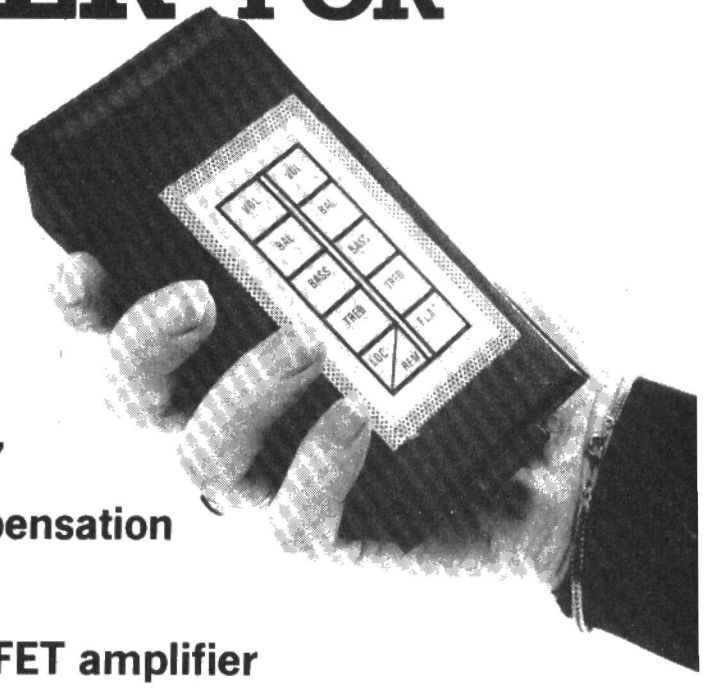



**Figure 10. Sine-square converter.**

*Continued on page 64*

# REMOTE CONTROLLER FOR 25W STEREO MOS-FET AMPLIFIER

*by Dave Goodman*



- ★ **Remote control over Volume, Bass, Treble and Balance**
- ★ **Switched loudness (contour) compensation**
- ★ **Local or remote select**
- ★ **Flat response select**
- ★ **Can be incorporated into our MOSFET amplifier**

Over recent years infra-red control has greatly increased in popularity, as is evident by the plethora of televisions and video cassette recorders fitted with this facility. Some hi-fi systems do incorporate remote control, but not very many, which is regrettable because sound level and balance settings are dictated by listening position in relation to the loudspeakers.

This hi-fi controller project gives the user total control over adjustment of volume and speaker balance settings, also bass and treble cut and boost. All operations are performed by pressing an appropriate button on the hand-held control transmitter. The selected parameter can then be either stepped by single shot or automatically swept by holding the button down. Two further controls allow for return from remote to local (or vice versa), and an instant flat setting of speaker balance and tone response.

A Pulse Position Modulation (PPM) dedicated integrated circuit is used in this design, based on the SL490 IC (see figure 2).

IC 1 is an encoder-oscillator and pulse train generator, producing a series of five pulses of fixed amplitude. Each pulse can vary in width, either 6ms or 9ms, according to whether a digital '1' or '0' is required (see figure 1).

Each one of the six 'spaces' between every pulse is of a consistent 1.25ms duration, and the pulse train repeats for as long as an encoding key is held operating.

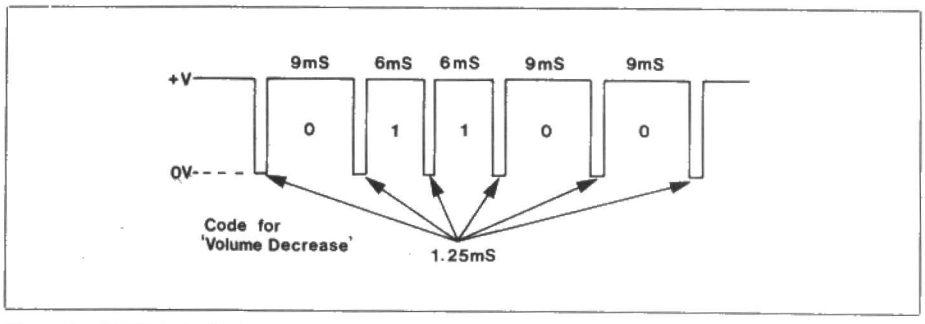



**Figure 1. P.P.M. Pulse Train.**

Switches S1 to S10 are PCB 'pads', and a ten-way bubble contact strip is used to join the appropriate pads together within the encoding matrix, pins 1, 4, 5, 8, and 10 to 13. Each bubble on the strip has an internal carbon contact of low electrical resistance, and applying pressure to the bubble flexes the contact down across the two pads. Table 1 lists each key, command, symbol, and pulse code used here and present on pin 2 of IC1.

**TABLE 1**

| Key | Command | Symbol | Pulse Code |
|---|---|---|---|
| S1 | Volume Down | | 01100 |
| S2 | Volume Up | | 00010 |
| S3 | Balance Left | | 11100 |
| S4 | Balance Right | | 10100 |
| S5 | Bass Cut | | 11110 |
| S6 | Bass Boost | + | 10110 |
| S7 | Treble Cut | - | 11111 |
| S8 | Treble Boost | + | 10111 |
| S9 | Local-Remote | LOC/REM | 11000 |
| S10 | Flat Response | Flat | 11011 |


| S9 | Local-Remote | LOC/REM | 11000 |
|---|---|---|---|
| S10 | Flat Response | Flat | 11011 |


C2 and R3 produce a differentiated signal of narrow width, and this is applied to the base of TR2. D1 prevents TR2 from becoming reverse biased. TR1 is a MOSFET device capable of switching large current pulses for only a small loading on the drive stages. Pulses from TR2 turn TR1 on and off, effectively forward biasing D2, 3, and 4. These three diodes are infra-red devices, and transmit light in the infra-red band (940nM). When TR1 is turned on these diodes appear connected between the supply rails, C1 discharges, and the current drawn from the battery would be high damaging the diodes and battery. To prevent this happening TR1 is turned on then off very fast, so that the 'on' time is far smaller than the 'off' time, producing a duty cycle of only a few per cent. The mean current drawn from the battery is therefore low, being approximately 15mA, and well within the 100mA rating of the TIL38 diodes.

C3 and RV1 set the transmission rate/internal clock of IC1 at approxi-

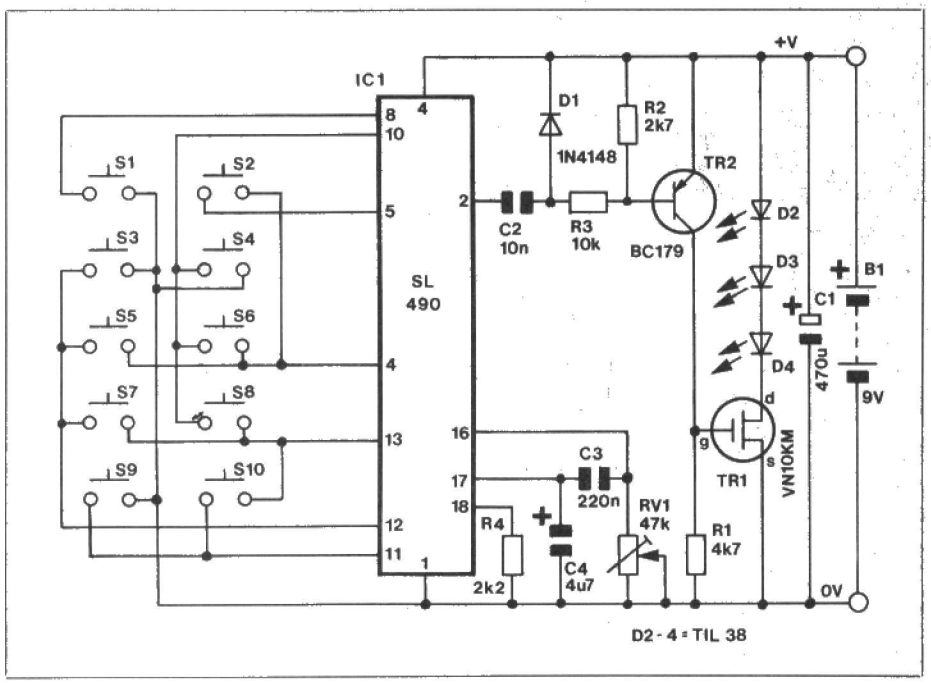



**Figure 2. Circuit diagram of Transmitter.**

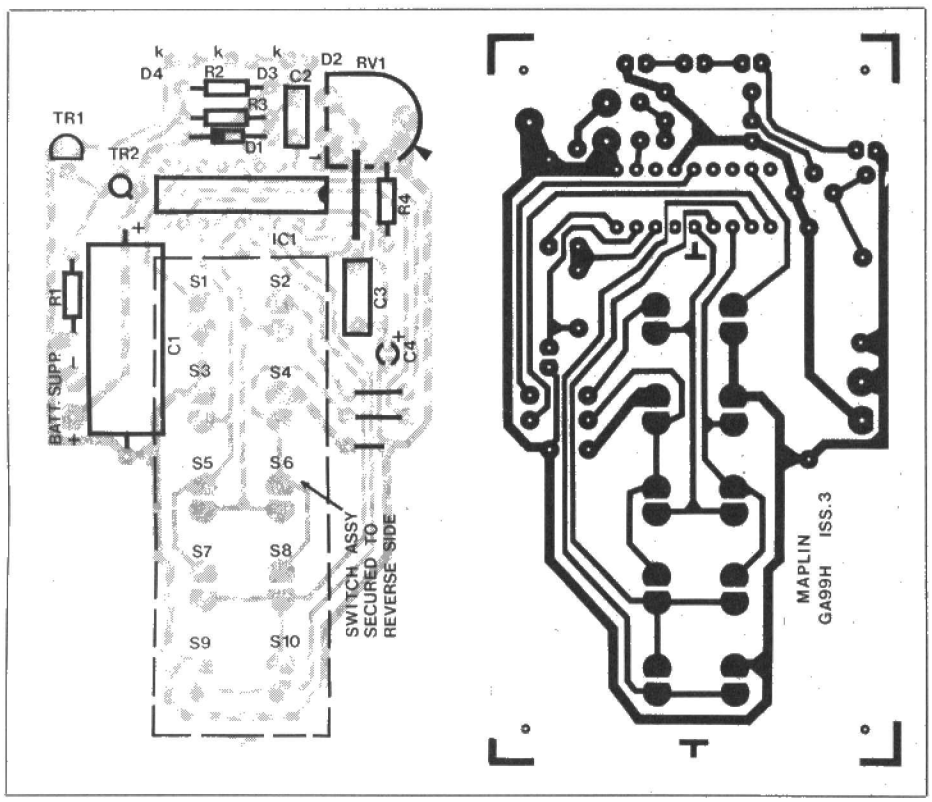
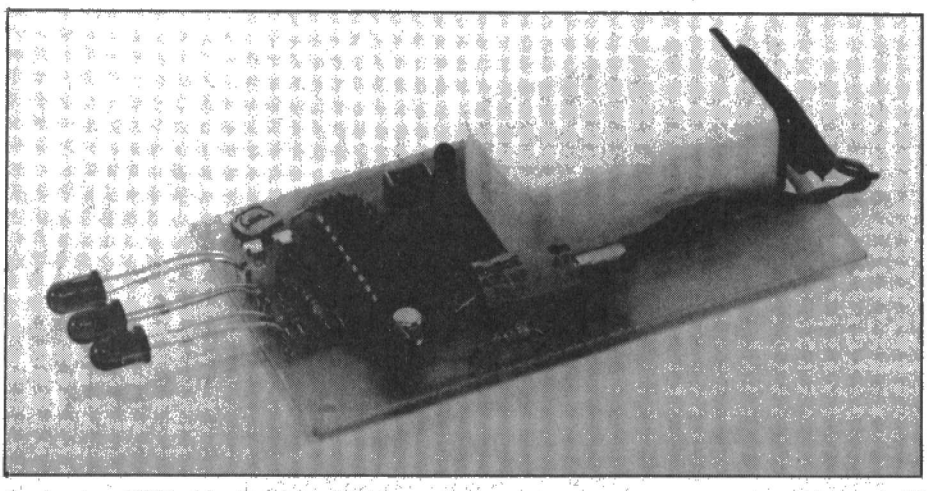



**Figure 3. Component Overlay for Transmitter PCB.**



mately 150Hz. Scope measurements can be made on pin 2 of IC1 with the 'treble cut' key S7 operated.

## Transmitter Assembly And Construction

Cut four pieces of wire for links, bend to shape and insert. Fit diode D1, followed by R1 to R4 and RV1. Mount all four capacitors. Note that C1 and C4 are polarised, and must be fitted one way only. C1 is marked with a negative sign on the case, whilst C4 is marked with a positive. Insert TR2, and ensure the 'pip' on the metal case aligns with the symbol on the legend (figure 3). Next mount TR1, also noting correct positioning. Fit the DIL socket for IC1, and proceed with soldering and trimming all component leads. Do NOT fit infrared diodes D2-4 at this stage. Clean the track with a suitable spirit and check for bad joints and short circuits.

The ten-way contact strip can now be fitted over the 'pads' on the track face of the PCB. Above and below these pads are two small 'T' symbols, which should be lined up with the two grooves situated along the centre line of this strip, one at each edge. These symbols do not connect electrically, and have been added solely as a guide for assembly. Use a contact type adhesive paringly around the edges of the strip, taking care not to spill over onto the carbon contacts. Remember that the glue will spread out once the strip is placed in position and pressed home, which might cover the PCB pads, so don't be too generous!

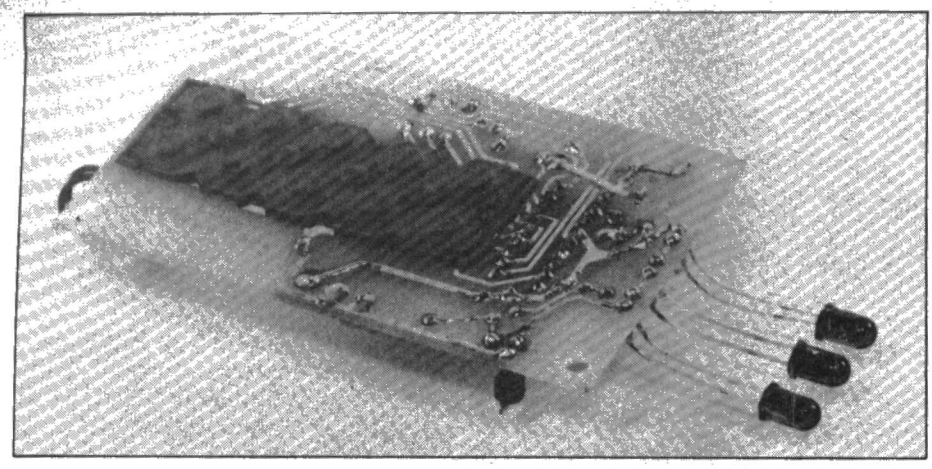
If you are satisfied with your efforts so far fit IC1 (SL490), and refer to the component lead configuration drawing for D2-4 description. All these LEDS may be fitted directly to the PCB, or connected with wires. Keep any wiring as short as possible. Finally, fit the battery clip. Check over all components and soldering once more before use.

## Transmitter Use

Set RV1 wiper just past halfway, to line up with the arrow printed on the legend. Connect a 9v battery to the clip, but only on one stud contact. Place an ammeter between the other battery contact and clip, so that it is in series with the positive rail. Press each bubble contact in turn. The ammeter reading should be 15-20mA each time, and only a few uA otherwise.

If there is no reading at all, or a much higher reading, check TR1, 2 orientation, D1 and C1 polarity, and D2-4 orientation. Of course, the contact strip may also be misaligned, and should be rechecked.

Now place a voltmeter from the negative rail (C1 neg. lead) to D4 cathode. A reading of 6.9v should be



apparent. Press any one of S1 to S10 contacts, and the reading should drop 200mv to 6.7v. These readings can vary slightly, but serve to give an indication that all is well.

No particular box is recommended for this project, but a flip-lid box type 601 (LQ03D) was used for the prototype. The LEDS mount through the front, and a suitable cut-out for the switches was made in the lid. The PCB can then be screwed or taped inside the lid, with the battery suitably accommodated underneath. A screened switch panel (RK36P) is available to fit over the contacts S1-10.

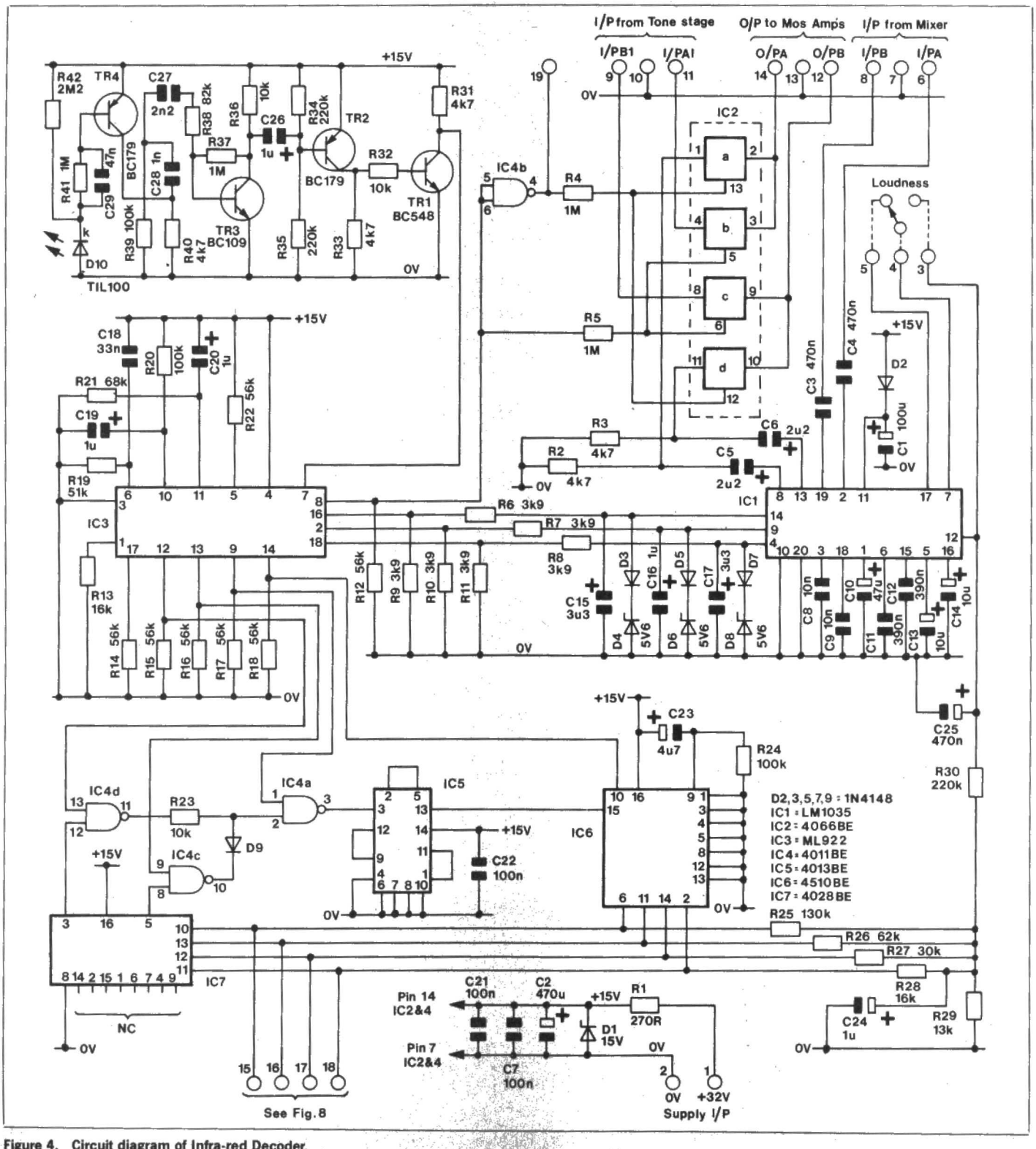
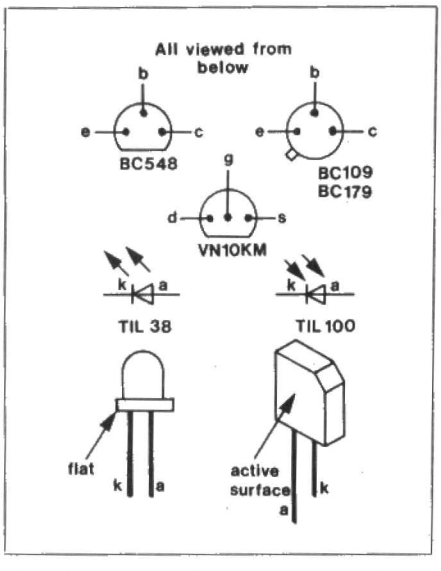



**Figure 4. Circuit diagram of Infra-red Decoder.**

# Decoder Circuit Description

P.P.M. data transmitted by the hand controller are received by D10 (figure 4), which is an infra-fred photodiode designed to react with signals of 940nM wavelength.

It is used in reverse bias mode and R42, 41, and C29 help prevent signals generated by incandescent or fluorescent light from becoming amplified. Quite considerable gain is required, to bring the incoming signals to a level suitable for correct operation, and circuit stability can become a problem.




Therefore two gain stages, comprising TR2 and TR3, have been incorporated. TR1 inverts the recovered pulse train so that it is in the correct sense and amplitude for use by IC3. PPM principles have been explained in the text previously, and reference can be made as necessary. IC3 (ML922), is a PPM decoder with one pulse, four digital, and three analogue outputs. An internal oscillator, with a clock frequency determined by C18 and R19, enables decoding of incoming pulse trains. R20 and C19 reset the decode circuits at switch-on, and C20 and R21 set the rate at which digital output codes step on. P16 controls bass, P18 controls treble, and P2 controls speaker balance. Only these three outputs step up and down about a 2.7v centre or 'flat' point, and are analogue channels. D3-8, C15-17, and R6-8 compress positive going voltage changes, thus producing a linear control of these functions within IC1. Pin 8 has a normally high output (+15v), holding the bilateral switches IC2b and c closed. IC4b, an inverter, holds IC2a and d open. Input signals from the MOSFET amplifier tone processing stages on pins 9 and 11 are thus connected via IC2 to pins 12 and 14 and, hence, to the power amp. stages (figure 6). Pre-processed signals are connected to input pins 6-8, and direct to IC1, which is a voltage controlled stereo, volume, and tone control IC. IC3, on receipt of a VOLUME UP or DOWN incoming pulse code, places a

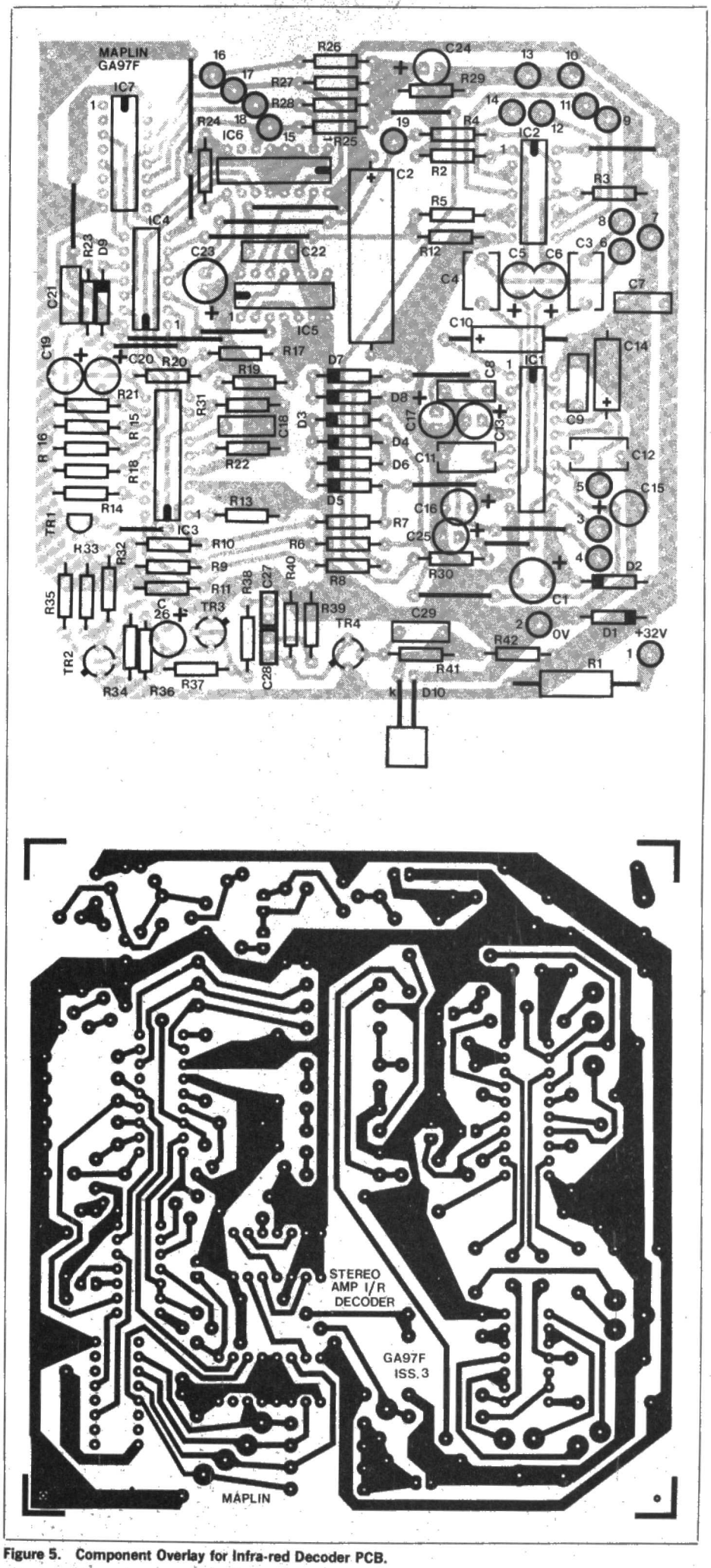



**Figure 5. Component Overlay for Infra-red Decoder PCB.**

low (0v) on pin 8. IC4b switches IC2a, d closed and IC2b, c open. Processed audio signals from IC1 are then transferred via C5,6, and IC2 to pins 12 and 14 and to the power amp stages.

Control of loudness (or contour) at low volume levels is achieved by connecting a change-over switch between pins 3, 4, and 5 as shown in figure 4. The action is local, and remote control of this facility has not been included. If loudness control is not required, then strap pins 4 and 5 together. C8 and 9 allow 15dB boost or cut at treble frequencies of 16kHz, whilst C12 and C13 allow 15dB boost or cut at bass frequencies of 40Hz.

ICs 4 to 7 are used to decode volume level commands. At power on, IC3 pins 12 to 14 are high (logic 1). Pin 14 determines volume 'direction', and is high for an increase or low for a decrease. Pin 9 is normally high with a negative going pulse output. Pin 13 is normally high and remains so for an up count switching low for a down count; whilst pin 12 is high for a down count and low for an up count. Table 2 should explain this more clearly.

| IC3 | PIN 12 | PIN 13 | PIN 14 | PIN 9 |
|---|---|---|---|---|
| Switch on | 1 | 1 | 1 | 1 |
| Volume increase | 0 | 1 | 1 | |
| Volume decrease | 1 | 0 | 0 | |

**TABLE 2**

IC6, a BCD up-down counter, generates a four bit binary output which is converted to an analogue voltage by R25 to 29, and fed via R30 to volume control input pin 12 of IC1. The stepped voltage ranges from 0v to +5.4v.

When a voltage step command is received IC3 pin 9 output pulses continuously at 15Hz, via IC4a, to IC5. The signal is then divided by four and steps IC6 through the up/down sequence. IC7, BCD to decimal decoder, examines all output codes from IC6, and gates IC4a output when one of two codes corresponding to either minimum or maximum volume are present. Otherwise, the volume sequence would keep running through max. to min. without control.

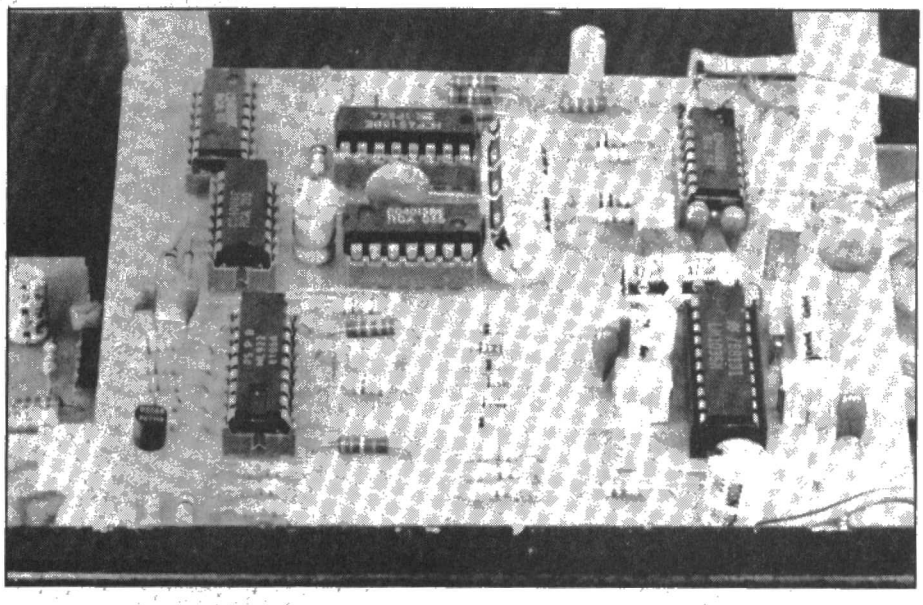
Figure 8 shows a BCD decoder to LED driver circuit, and has been included purely as an addition, not as part of the system. Connection can be made to pins 15-18 and +15v, 0v. Volume level settings are then displayed as numbers 0 to 9.

Finally, receipt of a 'flat' pulse code sets IC3 pins 2,16, and 18 to 2.7v internally. IC1 will interpret this as a flat response of bass and treble and even speaker balance.

# Construction

Refer to parts list and figure 5.

Start by making and inserting all sixteen links, diodes D1 to 9 (noting that D1,4,6, and 8 are zeners), and resistors



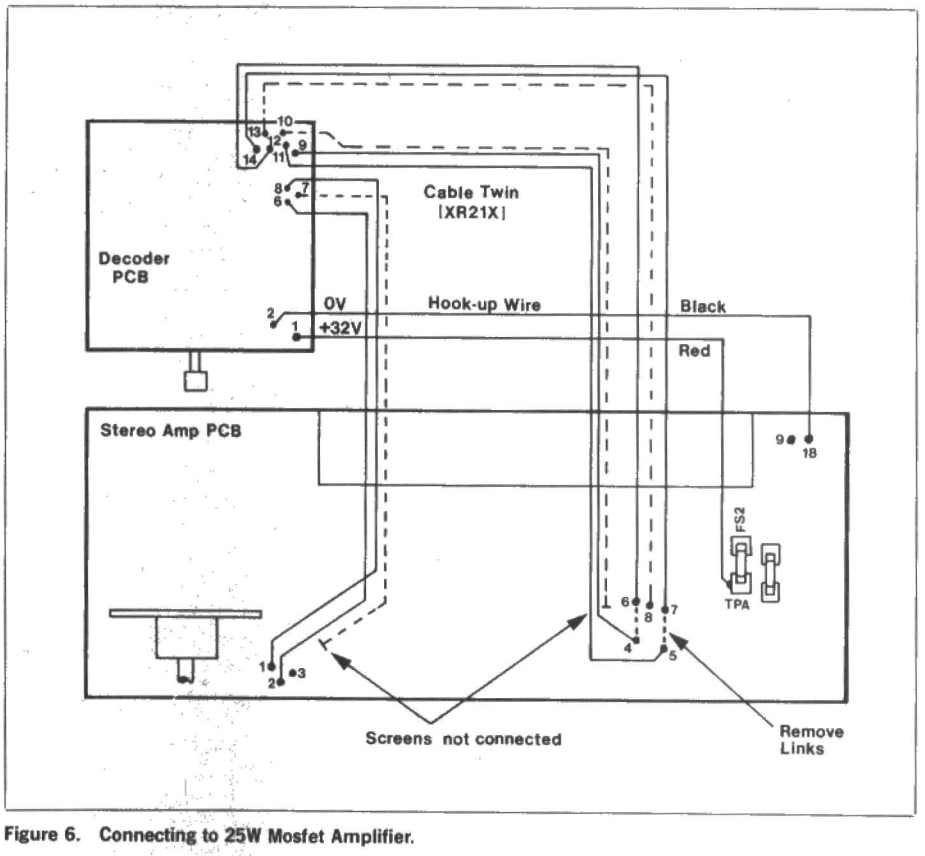



**Figure 6. Connecting to 25W Mosfet Amplifier.**

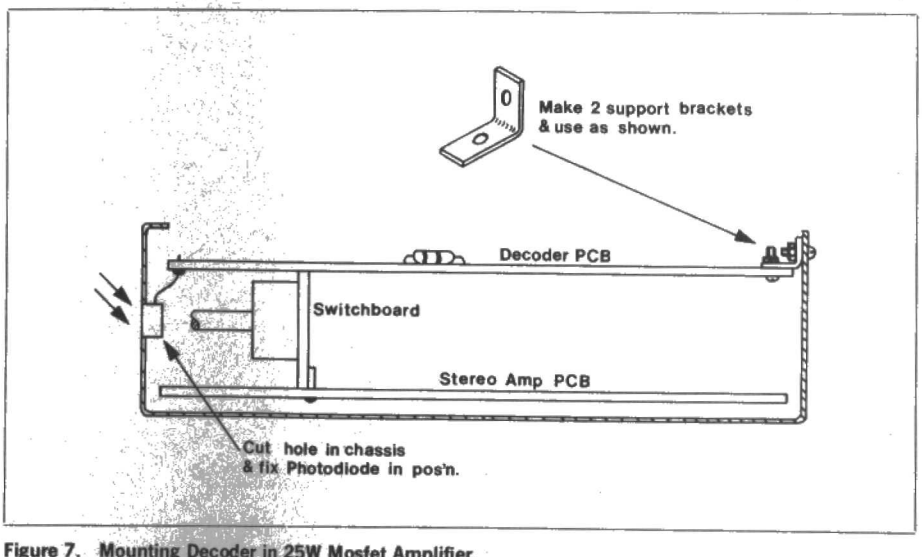



**Figure 7. Mounting Decoder in 25W Mosfet Amplifier.**

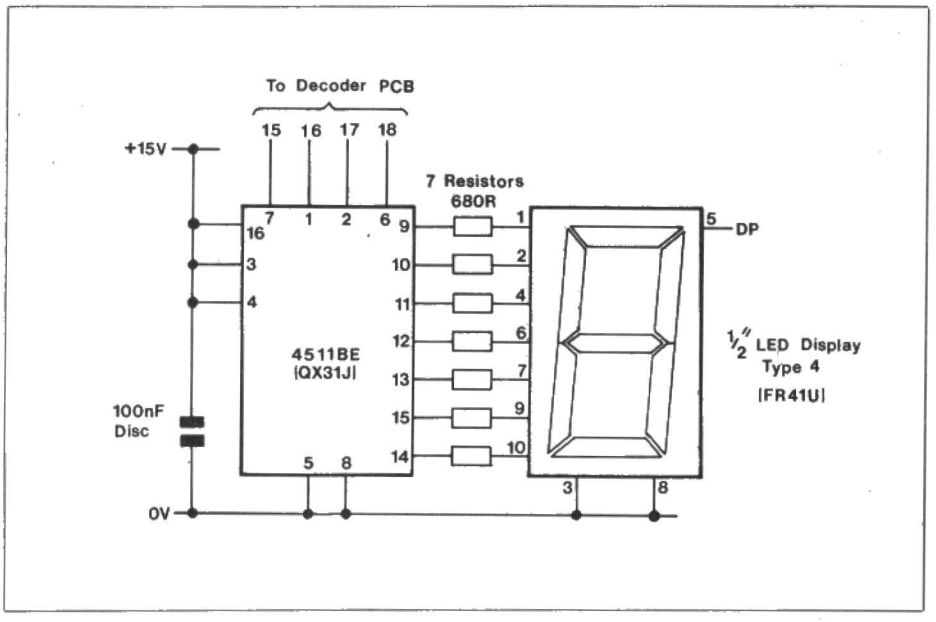



**Figure 8. LED Volume Indicator.**

R1 to 42. Some resistors are 1% tolerance, and should not be replaced by 5% min. types. R1 may get hot in use, and it would be advisable to mount this component a few mms above the PCB.

Axial, polycarbonate elactrolytic, and tantalum capacitors can be fitted next. Note that these components are polarised, and that tantalums have a positive sign, whilst all others have a negative sign. Fit all remaining capacitors, taking care not to bend the polycarbonate leads, as they are easily broken. Insert remaining transistors and IC holders.

Solder all parts carefully, and clean track surface to remove flux and possible short circuits. Faults are easier to find this way. Insert Vero-pins, if used, and fit all integrated circuits. A final check over is always well-advised before applying power.

## Assembly And Testing

Photodiode, D10, has one active and one insensitive side. Refer to the pin configuration drawing for correct use of this component, before fitting. On the prototype, D10 was fitted to the track side of the PCB, and inserted with the active area to the front.

When applying power, note that D1 and R1 are fitted for use with the +32v power supply from the MOSFET amp P.S.U. If available, a +15v power supply would be better for test purposes, and R1 will need to be bridged with a wire or clip, to avoide a large voltage drop across it.

Current consumption of the decoder should be approximately 55-60 mA, and a check with an ammeter in series with the positive supply will indicate this.

Use a voltmeter and check the following:

| | |
|---|---|
| IC3 | |
| pins 2,16,18 | +2.7v |
| pins 8,9,12,13,14 | +15v |
| pin 1 | +7v |
| pin 7 | 0v |
| IC1 | |
| pin 11 | +14.3v |
| pin 7 | +5.9v |
| | |
| TR2 collector | +15v |
| TR3 collector | +2.75v |
| TR4 collector | +1.5v |

all with respect to 0v

These voltage readings may vary by up to 4%, depending on the +15v rail regulation, so allow accordingly.

Connect the voltmeter to IC3 pin 7 (R31 is the most convenient place to clip on to), and the infra-red transmitter can now be used. Hold the transmitter two to three feet in front of the photo-diode (no closer!), and press S2, volume increase. A reading of between three and five volts can be expected, varying with alterations in range. Transfer the voltmeter to the common junction of R25 and 30, above pin 19. Switch the decoder off, then on again to reset. Repeat the transmitter operation, and check the meter reading steps as follows:

0.5v, 1.2v, 1.8v, 2.5v, 3.1v, 3.7v, 4.3v, 4.7v, and 5.2v. Connect the meter to IC3 pin 8. A reading of 0v will be indicated. Press S10 on the transmitter, and +15v should appear. Press S1 or S2 and the reading will change to 0v.

Connect the meter to IC3 pin 2. Switch off the decoder and re-apply power to reset. The reading will be 2.7v. Press S4 and the reading should swing up to +5.4v. Press S3 and reading will swing down to 0v. Repeat on IC3 pin 16, using S5 and S6, and IC3 pin 18, using S7/S8 on the transmitter.

The decoder PCB is now ready for use. If using in conjunction with our 25w MOSFET Amp project, refer to figure 6 for wiring details. A connection is made to TPA (+32v) using hook-up wire, for the positive supply. Do not forget to remove the short across R1 before connecting to TPA, otherwise the ICs will incur damage. All audio connections are made using screened wire, and should be kept as short as possible. Figure 7 shows the decoder mounted into the amplifier chassis above the switchboard. Brackets or sticky pads can be used for securing in position, and D10 can be mounted on the front panel as shown. Obviously, you do not have to do this, and an external box, with PSU, could be used instead; connections being made with DIN or PHONO plug leads and sockets.

Alternatively, the decoder may be used with any other audio system that has access sockets, either for tape in/out or pre-amp to power amp in/out. In this case wire pin 8 to pin 9, and pin 6 to pin 11. Signal inputs will then be on pin 6/8, and outputs on pins 12/14.

Switching between remote control and local control can then be effected, although in some circumstances a 'pop' may be heard in the speakers whilst doing so. *Continued on page 21*

## STEREO AMP I/R CONTROLLER PARTS LIST

Resistors – all ⅓W 5% carbon unless specified.

| | | |
|---|---|---|
| R1 | 4k7 | (M4K7) |
| R2 | 2k7 | (M2K7) |
| R3 | 10k | (M10K) |
| R4 | 2k2 | (M2K2) |
| RV1 | 47k hor-sub min preset | (WR60Q) |

Capacitors

| | | |
|---|---|---|
| C1 | 470uF 10V axial electrolytic | (FB71N) |
| C2 | 10nF disc ceramic | (BX00A) |
| C3 | 220nF polycarbonate | (WW45Y) |
| C4 | 4u7F 16V tantalum | (WW64U) |

Semiconductors

| | | | |
|---|---|---|---|
| D1 | 1N4148 | | (QL80B) |
| D2,3,4 | TIL 38 | 3 off | (YH70M) |
| TR1 | VN10KM | | (QQ27E) |
| TR2 | BC179 | | (QB54J) |
| IC1 | SL490 | | (YH66W) |

Miscellaneous

| | | |
|---|---|---|
| S1-10inc | Switch contacts (10 way) | (YR71N) |
| B1 | NICAD PP3 | (HW31J) |
| | Battery clip | (HF28F) |
| | Veropin 2141 | (FL21X) |
| | Flip-top Box 601 | (LQ03D) |
| | P.C.B. | (GA99H) |
| | Switch panel | (RK36P) |

For kit details see Decoder Parts List on page 21.

# CAR BURGLAR ALARM

*by Keith Baker*

There are many car alarms available on the market, but none can offer complete protection against theft. Though no alarm will foil the professional thief, it will act as a deterrent to the small time thief or joyrider. This circuit, like most alarms, is triggered off by the door contacts for the courtesy light and will only work when fitted to a 12V negative earth car. The switch to the alarm is fitted on the inside of the car as opposed to the outside, thus ensuring that the switch is not tampered with.

The idea is, that when leaving the car the alarm switch is turned to the on position and the 'arm' button is pressed. It is now safe to open the doors and get out of the car. After pressing the 'arm' button a timer circuit allows approximately 60 seconds to leave the car and shut the doors. After the 60 seconds, providing the doors are shut, the circuit will arm itself. If a door is then opened, the horn will sound after 15 seconds. This 15 second delay is sufficient time for the occupant to turn off the alarm, but not enough time for the thief to tamper with the switch. The horn will sound for a further 1½ minutes and the alarm will then arm itself again. If the door is left open the alarm will sound continuously.

## The Circuit

Figure 1 shows the circuit diagram of the alarm and this is based on three timer circuits.

When the car door is opened the negative side of C2 is biased negative, C2 is charged and TR2 is biased hard on. TR2 now conducts down to -V and RLB changes over.

With RLB in its normal condition, it is keeping C3 fully charged and TR3 biased hard on. When RLB changes over, as described above, C3 starts discharging as R4 goes positive. In this state RLC is being shorted out, but as C3 discharges, the voltage drop across the collector and emitter of TR3 becomes larger until RLC 'pulls in' (approximately 15 seconds from RLB changeover). This causes +12V to be transmitted to the horn and allows C2 to start discharging.

When the base emitter voltage of TR2 starts to decrease, the voltage drop across RLB also decreases, until RLB 'drops out' cutting off the supply to RLC, which in turn cuts off the horn.

When leaving the car, to prevent the alarm circuit energising, C2 has to be kept discharged. This is done by making a break in the negative potential supplied by the door contacts for the courtesy light. By turning on the supply and pressing the push to make button S2, C1 charges up, TR1 turns hard on and RLA changes over, making a break between the door contacts and the negative side of C2.

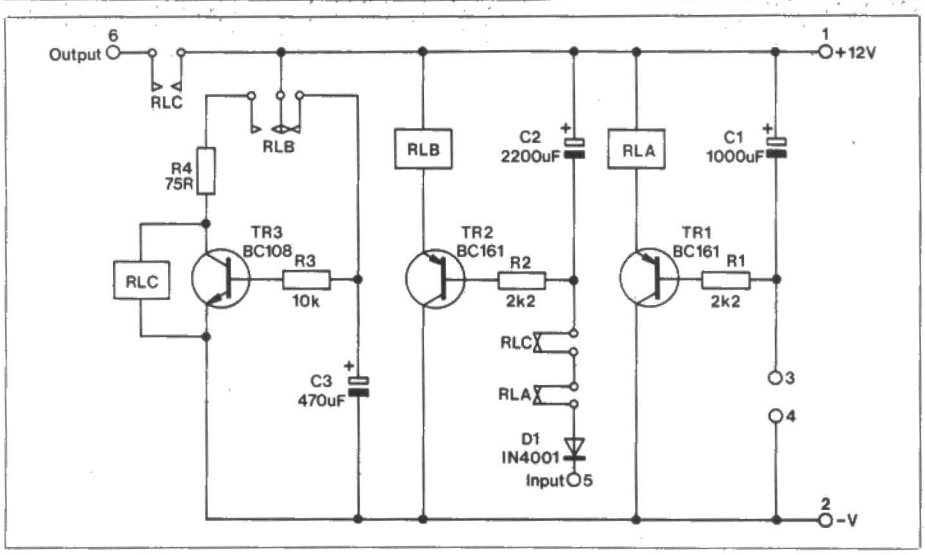



**Figure 1. Circuit diagram.**

R4 is in the circuit to provide a load when TR3 is biased hard on. D1 is in the circuit to prevent C2 from discharging. R1, R2 and R3 govern the discharge rate of capacitors C1, C2 and C3 respectively. These values can be varied to alter the time delays.

## Construction

The complete circuit fits into a small plastic box 71.5mm x 49mm x 24.5mm and it is therefore suggested that a PCB is used. The track side and component side of this can be seen in Figure 2. Fit and solder into position the resistors and the diode, then mount RLA, B & C, TR1, 2 & 3 and solder in position. Lastly, fit C1, 2 & 3 taking note of capacitor polarity.

On the completion of the circuit board, a small hole can be drilled in the box, as an exit for the wires and a piece of plastic foam at the top and bottom of the completed PCB will protect it when installed. The supply switch is inserted in the circuit between supply and +12V.

For cheapness, a concealed switch can be used, e.g. fitted under the dashboard or in the glove compartment etc. A key switch proves quite effective and is relatively easy to install. The most novel idea is a combination lock, a simple version of which is shown in Figure 3.

The switch arrangement is achieved by using three 1 pole 12 way rotary switches. By connecting all of the terminals of the switch together except one, there is only one position where the switch will not conduct from the outside terminals to the inside pole. By connecting the three switches as shown, there is only one combination that will cut off the supply. In the example it is 6, 3, 6. These three switches connected in this way allow a possible 1728 different combinations.

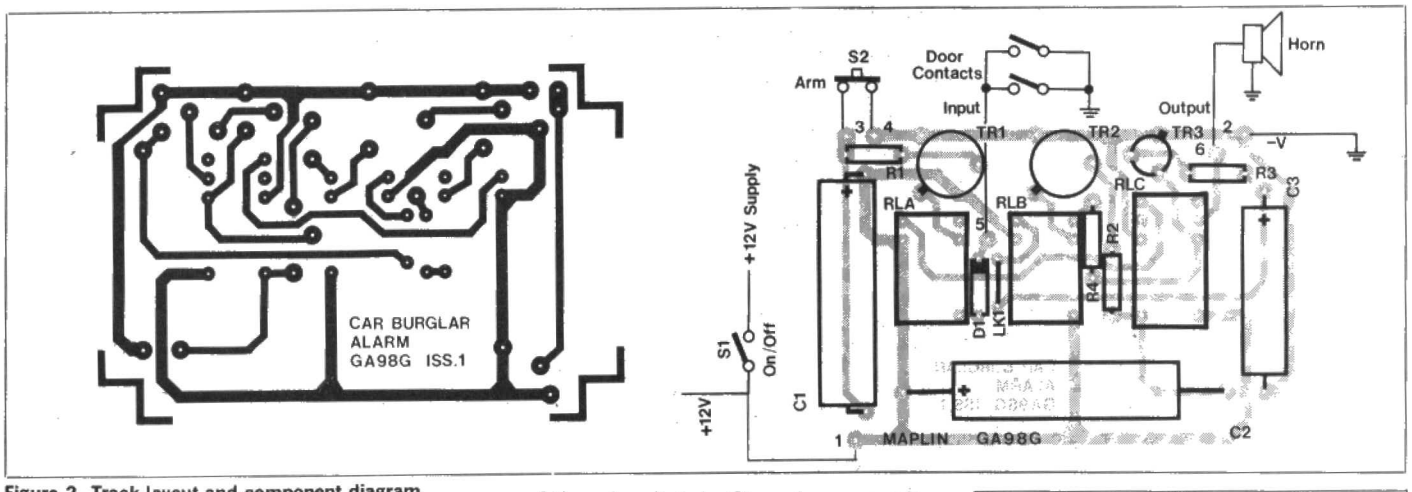



**Figure 2. Track layout and component diagram.**

## Installation

With reference to Figure 2 proceed as follows:

1. Find a convenient positive supply source and fit one of the switches as described in the previous paragraph, between the supply and the +12V of the circuit (pin 1).
2. Take a single wire from the negative of the circuit (pin 2) and connect it to a metal part of the car body.
3. Take a single wire from the negative side of the courtesy light and connect to INPUT (pin 5).
4. Take a single wire from the positive horn contact and connect it to OUTPUT (pin 6).
5. Fix the 'arm' button to a convenient position on the dashboard and connect to the PCB at pins marked 3 & 4.

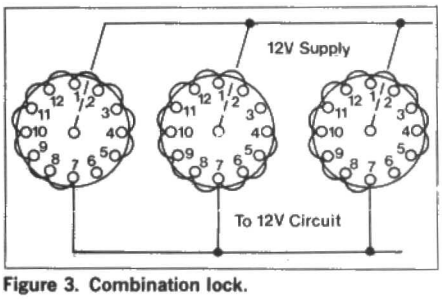



**Figure 3. Combination lock.**

## CAR BURGLAR ALARM PARTS LIST

| | | | Maplin Code |
|---|---|---|---|
| Resistors — all ¼W 5% carbon unless specified | | | |
| R1,2 | 2k2 | 2 off | (M2K2) |
| R3 | 10k | | (M10K) |
| R4 | 75R (½W) | | (S75R) |
| Capacitors | | | |
| C1 | 1000uF 16V axial electrolytic | | (FB82D) |
| C2 | 2200uF 25V axial electrolytic | | (FB90X) |
| C3 | 470uF 16V axial electrolytic | | (FB72P) |
| Semiconductors | | | |
| TR1,2 | BC161 | 2 off | (QB49D) |
| TR3 | BC108 | | (QB32K) |
| D1 | 1N4001 | | (QL73Q) |
| Miscellaneous | | | |
| RLA,B | Ultra-min relay SPDT | 2 off | (YX94C) |
| RLC | Ultra-min relay DPDT | | (YX95D) |
| S1 | See text | | — |
| S2 | Push switch | | (FH59P) |
| | Verobox 301 | | (LL12N) |
| | Veropin 2145 | 6 off | (FL24B) |
| | PCB | | (GA98G) |
| | Wire | | As required |

A complete kit of parts is available for this project.
**Order As LW78K (Car Burglar Alarm Kit). Price £6.95**

# IR REMOTE CONTROLLER

Continued from page 19

Maximum range is quite good, and may be improved by careful adjustment of RV1 on the transmitter PCB. Most average sized rooms should be adequately covered, but close range use (i.e. three feet or less) may not work reliably, and local control is preferable here. When first switching everything on, the decoder will be in local control mode; remote control is effected by pressing the volume buttons. Set bass, treble, and balance to suit, or press LOC/REM button for return to local control. When changing control from local to remote all other settings switch 'flat' and will need re-adjustment as necessary with the appropriate button.

## PARTS LIST — STEREO AMP I/R DECODER

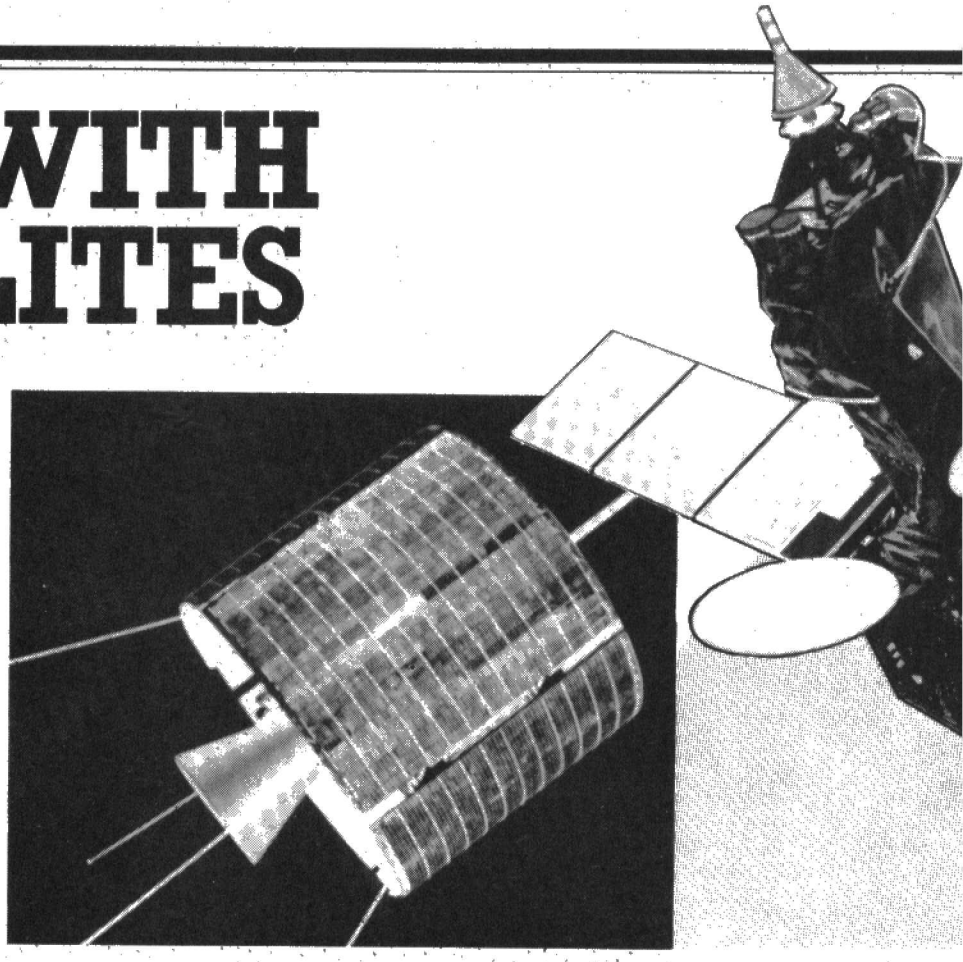
| | | | |
|---|---|---|---|
| Resistors — all ¼W 5% carbon unless specified. | | | |
| R1 | 270R (3W) wirewound | | (W270R) |
| R2,3,31,33,40 | 4k7 | 5 off | (M4K7) |
| R4,5,37,41 | 1M0 | 4 off | (M1M) |
| R6-11 | 3k9 | 6 off | (M3K9) |
| R12,14-18inc.,22 | 56k | 7 off | (M56K) |
| R13 | 16k (½W 1%) | | (T16K) |
| R19 | 51k (½W 1%) | | (T51K) |
| R20,24,39 | 100k | 3 off | (M100K) |
| R21 | 68k | | (M68K) |
| R23,32,36 | 10k | 3 off | (M10K) |
| R25 | 130k (½W 1%) | | (T130K) |
| R26 | 62k (½W 1%) | | (T62K) |
| R27 | 30k (½W 1%) | | (T30K) |
| R28 | 16k (½W 1%) | | (T16K) |
| R29 | 13k (½W 1%) | | (T13K) |
| R30,34,35 | 220k | 3 off | (M220K) |
| R38 | 82k | | (M82K) |
| R42 | 2M2 (10%) | | (M2M2) |
| Capacitors | | | |
| C1 | 100uF 25V P.C. electrolytic | | (FF11M) |
| C2 | 470uF 16V axial electrolytic | | (FB72P) |
| C3,4 | 470nF polycarbonate | 2 off | (WW49D) |
| C5,6 | 2u2F 35V tantalum | 2 off | (WW62S) |
| C7,21,22 | 100nF disc ceramic | 3 off | (BX03D) |
| C8,9 | 10nF polycarbonate | 2 off | (WW29G) |
| C10 | 47uF 25V axial electrolytic | | (FB39N) |
| C11,12 | 390nF polycarbonate | 2 off | (WW48C) |
| C13 | 10uF 35V P.C. electrolytic | | (FF04E) |
| C14 | 10uF 25V axial electrolytic | | (FB22Y) |
| C15,17 | 3u3F 35V tantalum | 2 off | (WW63T) |
| C16,19,20,26 | 1uF 35V tantalum | 4 off | (WW60Q) |
| C18 | 33nf polycarbonate | | (WW35Q) |
| C23 | 4u7F 63V P.C. electrolytic | | (FF03D) |
| C24 | 1uF 100V P.C. electrolytic | | (FF01B) |
| C25 | 470nF 100V P.C. electrolytic | | (FF00A) |
| C27 | 2n2F ceramic | | (WX72P) |
| C28 | 1nF ceramic | | (WX68Y) |
| C29 | 47nF polycarbonate | | (WW37S) |
| Semiconductors | | | |
| D1 | BZX61C15V | | (QF57M) |
| D2,3,5,7,9 | 1N4148 | 5 off | (QL80B) |
| D4,6,8 | BZY88C5V6 | 3 off | (QH08J) |
| D10 | TIL 100 | | (YH71N) |
| TR1 | BC548 | | (QB73Q) |
| TR2,4 | BC179 | 2 off | (QB54J) |
| TR3 | BC109c | | (QB33L) |
| IC1 | LM1035 | | (QY19V) |
| IC2 | 4066 BE | | (QX23A) |
| IC3 | ML922 | | (YH67X) |
| IC4 | 4011 BE | | (QX05F) |
| IC5 | 4013 BE | | (QX07H) |
| IC6 | 4510 BE | | (QW83E) |
| IC7 | 4028 BE | | (QX17T) |
| Miscellaneous | | | |
| | Veropin 2141 | 19 off | (FL21X) |
| | P.C.B. | | (GA97F) |

A complete kit of all the parts needed to build the Encoder and Decoder are available.
**Order As LW77J (Amp Remote Control Kit). Price £26.95**

# SAY IT WITH SATELLITES

*by Mike Wharton*

## Part 1: The historical background



In 1945 a young engineer with an interest in science fiction had an article published in 'Wireless World' which was to change the face of radio communication. At the time the Editor concerned debated whether the ideas contained in the article were more fancy than fact, but he took a gamble and, one supposes, hoped for the best. The article explained how it should be possible for radio communication to be extended over ranges far exceeding those then available by the use of a transmitter out in space. The author of the article was Arthur C. Clarke, whose name has since become world-famous.

At the time the original article was published the technology required to build and launch an artificial satellite into a geostationary orbit barely existed. Clarke's great foresight was to realise that the Second World War had produced a variety of machines and techniques which, developed in the right direction, could achieve this goal. For example, the German V-rockets had been brought to a stage of design where a multi-stage version could have reached New York from Europe; if it could do that, then it could also put a satellite into orbit.

Such technology was not to be used for this purpose immediately, although the rockets were continually refined, but with a view to improving the long range strike capability of the American and Russian war machines.

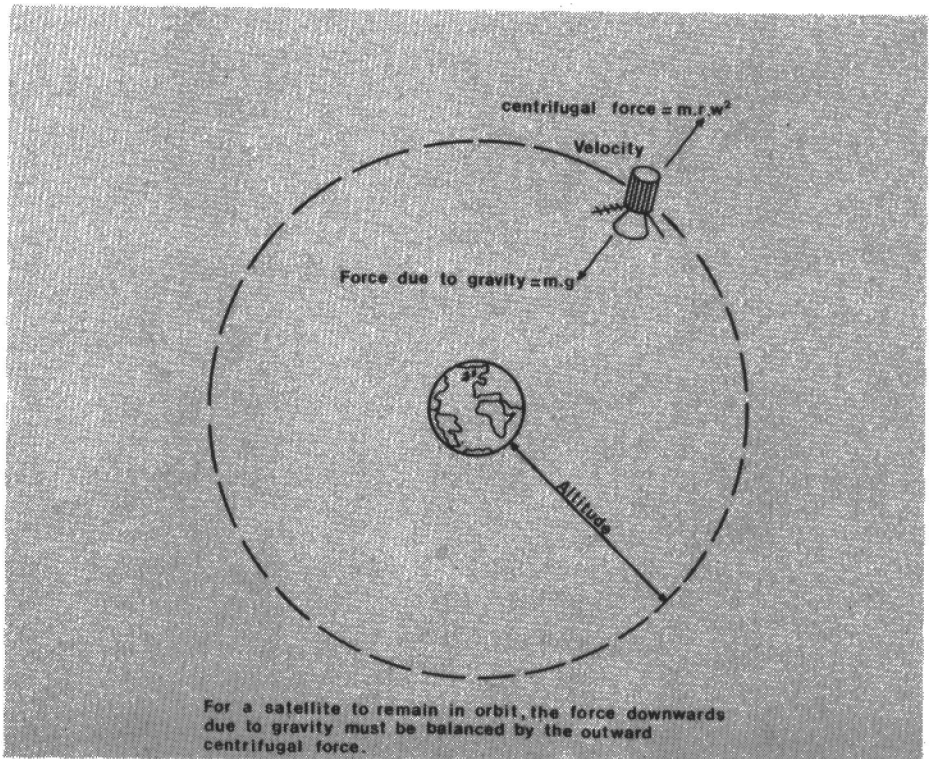
As the race to achieve space supremacy between these two powers continued, the so-called 'Space Race', the peaceful use of satellites was eclipsed. It was not until October 1957, when the Russians successfully put Sputnik 1 into orbit, that the attention of the public was focussed onto this 'final frontier'. The thought that the Russians might be winning the space race galvanised the Americans into action, and made it politically possible for the expenditure of the billions of dollars involved in such a venture. Initially, much of this money went into putting men, rather than satellites, into space, but this provided the necessary hardware and technical back-up for the delicate task of placing such a package into a precise orbit.

The next step along the road towards the present day proliferation of communication satellites came in July 1962, with the launch of Telstar by NASA. This was a low-orbiting satellite because the available technology was unable to push it far enough out into space to take up a geostationary orbit. Such low orbit satellites need to be tracked as they encircle the globe, and this results in the use of expensive, computer-controlled antenna systems, such as those which may be seen on Goonhilly Downs in Cornwall. Telstar's elliptical orbit and speed of 18,000 mph made such tracking difficult, with possibly only sixty minutes good communication time per day between any two locations.

Some readers, however, may recall that it was sufficiently eventful to inspire a pop record by the Tornadoes, which even attempted to recreate the AOS (Acquisition of Satellite) and LOS (Loss of Satellite) at the beginning and end of the record.

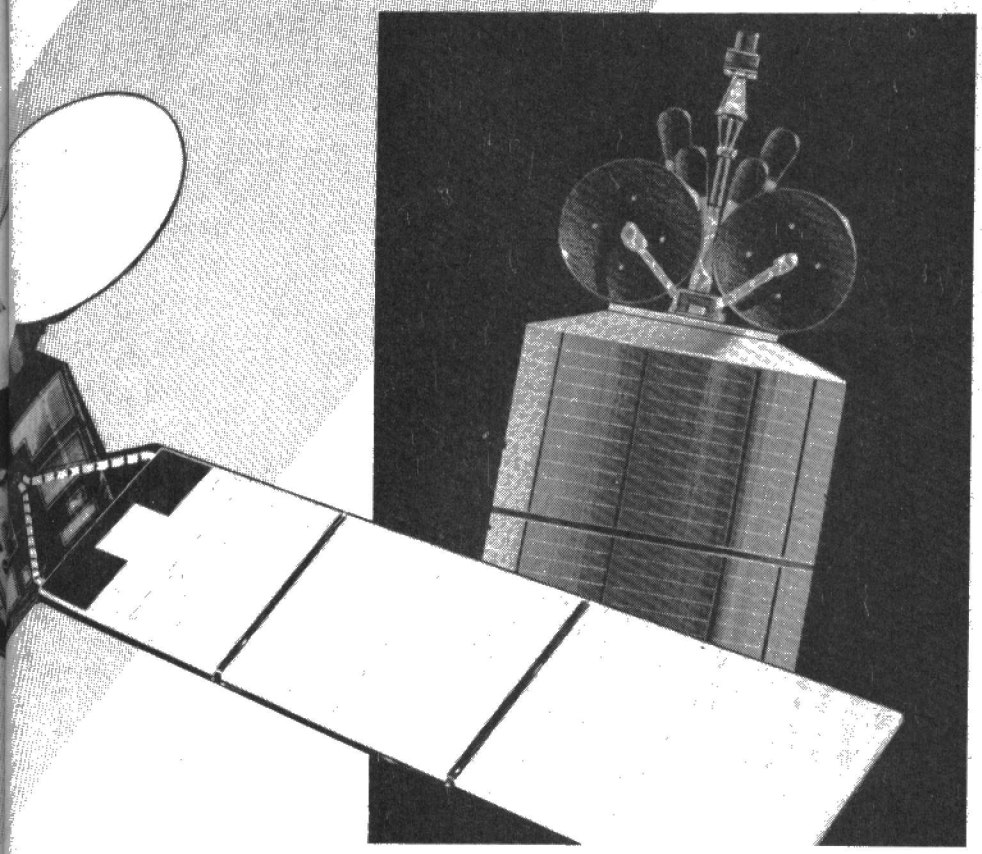
For a satellite to remain in orbit it is necessary for it to revolve around the Earth, so that the downward pull of gravity is balanced by the outward centrifugal force, as shown in Figure 1. In order for the satellite to appear to remain stationary over one point on the Earth's surface, it must rotate at the same speed as the Earth, and in the same direction. Figure 2 shows the orbital velocity against altitude, and it can be seen that for a satellite to remain in such a geostationary orbit it must be pushed out into space to a distance of about 36,000 km (22,400 mls).

One of the first satellites to be put into such an orbit was INTELSAT 1, or 'Early Bird', as it was originally called. It was launched in July 1965 and measured 60 cms long by 72 cms diameter and weighed under 70 kg. This satellite could handle 240 voice channels or just one TV channel, and although designed for a life of 18 months was still going strong more than three years later. There quickly followed further INTELSAT's, despite the failure of the first of the INTELSAT 2 and 3 series, so that by the time man first set foot on the moon on 20th July 1969 INTELSAT was able to transmit live TV pictures of this historic event around the world. As a result of these satellites placed in




For a satellite to remain in orbit, the force downwards due to gravity must be balanced by the outward centrifugal force.

**Figure 1.**



geostationary orbits at various points over the globe, the term 'live by satellite' became a TV catch-phrase increasingly familiar to viewers across the world.

Since those early days in satellite communications, the number in orbit around the earth has increased enormously and there are now literally thousands, with all manner of different capabilities. These range from what might be termed the commercial communication types to the military 'spy-in-the-sky' and navigation satellites. They have become big business, and, besides the conventional communications satellites, there are those like Meteosat and Tiros-N which are used by meteorologists to observe the movement of weather patterns. Some of this class of satellites have extremely good imaging systems, like Land-sat, and are used by geologists to seek out surface features in the search for oil and mineral deposits. By gathering information from such satellites over a period of time, it is possible to build up a comprehensive picture of the whole globe.

This provides the means to predict what the Russian grain harvest will be six months before it is harvested, which has obvious political implications. With such a potential capability at its disposal, it is not surprising that military interest in satellites has grown considerably. There are now American satellites out in space which are reputed to be able to 'read' a newspaper headline. It may not be a joke that on the flat roof of a CIA building in America are written the words, in Russian, 'when you can read this you are five years behind'.

The next development in satellite communication has already made a start in the USA, that of Direct Broadcasting by Satellite or DBS. Because of the size of the North American continent it makes a lot of sense to use small satellites for radio communication due to the necessarily limited range of ground-based transmitting stations. There are in existence a number of such satellites, like the Westar group, launched by Western Union between 1974 and 1979. This is a group of three satellites positioned over the equator in geostationary orbits; Westar 1 is in line with San Antonio, Texas, Westar 2 with San Francisco, and Westar 3 with Baton Rouge, Louisiana. Together they give coverage for the transmission of data, TV, voice and facsimile communications traffic across the continent.

Although this type of satellite was not originally intended for direct broadcasting to the public at large, enterprising experimenters soon discovered that with a modest amount of effort and equipment it was perfectly possible to intercept the transmissions beamed to earth. The fact that one was able to eavesdrop on what had hitherto been regarded as 'private' communication links probably had more to do with its popularity than the actual programmes received. One thing it did demonstrate, however, was that with a satellite in a geostationary orbit, the need for extremely sensitive and expensive steerable receiver antennae could be done away with. This immediately opens up a whole new field of possibilities, and the American satellite business was not slow to realise the enormous potential involved.

For experimenters of a similar mind in this country the picture is not quite the same (pun not intended). As far as receiving TV transmissions is concerned there is not, as yet, anything to compare with those over North America. The only one of this type visible from Britain is the Russian Gorizont satellite. Needless to say, even to receive it one cannot just get a big antenna pointed in its general direction and plugged into a normal TV set. Differing standards of picture transmission apart, one of the biggest problems to overcome is that of the frequency of the down-link signal. To make the best use of the available bandwidth, and because other frequencies have long been allocated to different uses, the signals transmitted by these satellites lie in the Giga-hertz range; for example, the North American standard has a spectrum of 3.7 to 4.2 GHz.

The design of receivers and tuners at this frequency seems to owe more to black magic than maths, and the down-link frequency for the proposed European DBS transmissions will be around 12 GHz, in order that smaller receiver dishes may be used. On the other hand, for those interested in receiving signals from a satellite, then the various Amateur satellites probably offer the best scope for experimentation. There are a number of these in orbit, called OSCAR's (Orbital Satellites Carrying Amateur Radio), as well as the recently launched Russian ones. Although they are intended to be used as transponders to increase the range of Amateur radio transmissions, the latest of the series, OSCAR 9, has a TV camera and voice synthesiser on board. Also, the down-link frequency of these transmissions is 145 MHz, and the next article will look at these satellites in more detail.

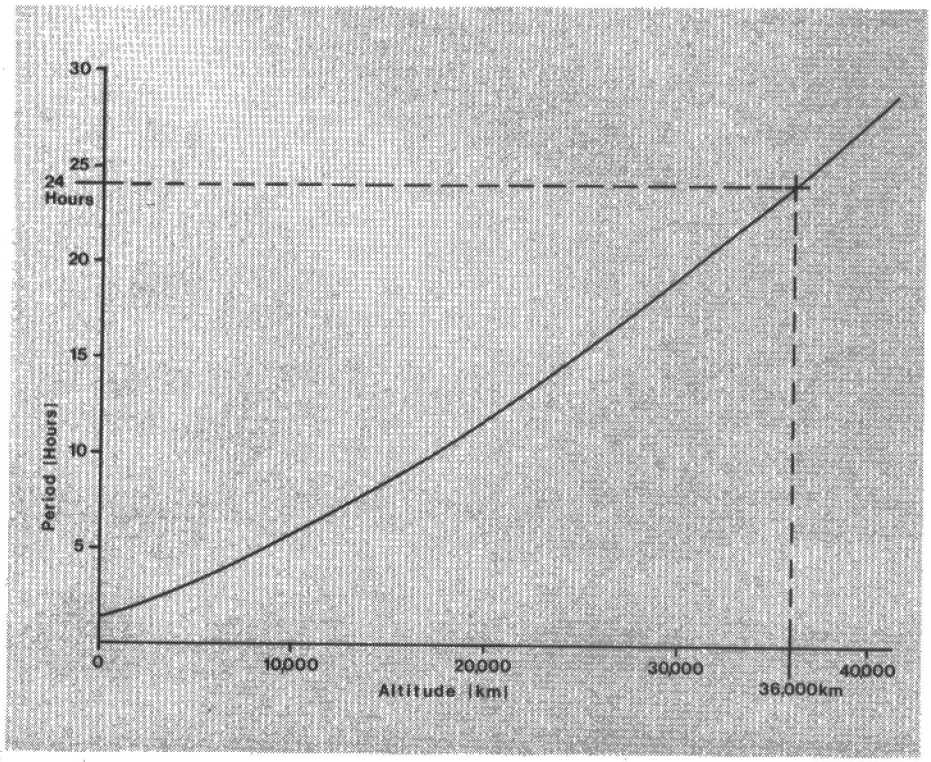



**Figure 2.**

# THE SEALED NICKEL CADMIUM BATTERY

*by W. D. C. Walker, B.Sc., C.Chem., M.R.S.C.*

Sealed, maintenance-free rechargeable batteries are becoming increasingly readily available to the model maker, handyman, radio enthusiast and electronics engineer. Until recently they have served the public in a somewhat hidden way, as components of 'rechargeable' razors, calculators etc. Nowadays they can be obtained off the shelf, and for most purposes only a small amount of knowledge on simple charging techniques is necessary. Single units are referred to as 'cells', and these can be connected together into 'batteries'.

We shall be considering the sealed nickel-cadmium cells and batteries, which are the 'maids of all work' in the small power source field.

Probably the most important facts are:—

1. The cell discharge voltages are essentially the same as those of 'dry' cells, i.e. zinc/carbon or alkaline manganese;
2. Some nickel-cadmium cells have exactly the same dimensions as the common dry cells and can be interchanged;
3. Their discharge currents can be drawn continuously, and very rapidly as required
4. They can be recharged and discharged a great number of times; 500 or 1,000 times, or many more depending on use;
5. They can be left on continuous charge for years, and thereby maintained in a constant, fully charged state of readiness.

There are, of course, a few 'ifs' and 'buts' relating to the above and we shall consider these below.

There are two basic types of sealed nickel cadmium cell: the 'cylindrical' cells and the 'button' cells. A mixed group is shown in Figure 1, and Figures 2 and 3 illustrate construction differences and similarities. Respectively tables 1 and 2 give details of the available sizes of the two kinds.

Note that the nickel cadmium cells which are interchangeable with dry batteries are to be found amongst the cylindricals, and Table 1 includes references to the non-rechargeable zinc-carbon and alkaline-manganese equivalents. We shall deal with the cylindrical cells first.

## Cylindrical Cells

As an example, consider a nickel cadmium cell of penlight size, the AN 50. It can be left permanently on charge at currents of up to 65mA; it can deliver 10A for 30 seconds; 5A for 3 minutes; or 0.5A for 1 hour. All this can be done in any position, and cycles of charge and discharge can be repeated hundreds or thousands of times. It has the same dimensions as the penlight HP7 and MN1500, and can be used in temperatures as low as -30°C, and as high as +50°C, and attains at least half capacity at the extremes.

How is this versatility achieved? The main secret is in the 'Oxygen Recombination Reaction', which means that the gas produced internally on overcharge is absorbed continuously and re-used inside the sealed cell in accordance with the reaction:—

$$O_2 + 2\,H_2O + 2\,Cd \rightarrow 2\,Cd(OH)_2$$

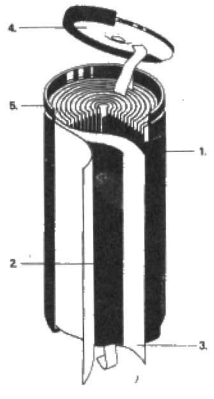
The oxygen is given off at the positive (nickel) electrode and reacts very quickly with the cadmium in the charged negative electrode. To help this reaction in the cell the two electrodes are separated only by a thin porous membrane. Cylindrical cells are spirally wound (as shown in Figure 2), whereas button cells consist of flat plates (as shown in the sectional drawing in Figure 3). The electrode 'plates' are made containing finely divided 'active' materials, nickel hydroxide for the positive and cadmium hydroxide for the negative. These materials are absorbed into a sintered or an electro-deposited metal matrix, and this type of construction gives the very low internal resistances and the correspondingly high short-circuit currents shown in Figure 4.

Note that the cylindrical cells are fitted with a re-sealing one-way safety vent that relieves any excess internal pressure caused by a fault or abuse. It opens at about 200 psi and closes again at about 175 psi. Typical abuse conditions would be overcharging at too high a current or excessive reverse charging.

The electrical capacity of a secondary (i.e. rechargeable) cell is expressed in Ampere hours (Ah) or for small cells in milli-Ampere hours (mAh). It depends on the rate of discharge, and it is common practice to measure it at the 5-hour rate. It will be seen from Table 1 that the cylindricals come in a wide range of capacities, from 110 mAh to 10 Ah.

Cells can be connected together in series to produce batteries. Only cells of the same capacity should be used. Connecting in series increases the voltage but the resulting battery has the same ampere hour capacity as the individual cells. Thus ten 4 Ah cells connected in series will give a battery of 12

**Figure 1. Various Ni-Cad batteries**




1. **Sintered nickel positive electrode.**
2. **Electrodeposited cadmium negative electrode.**
3. **Separator.**
4. **Top cover with resealing safety vent.**
5. **Nickel plated steel can.**
6. **Electrolyte.**

**Figure 2. Construction of a 4.5 Ah cylindrical cell (AN450).**

| Ever Ready Catalogue Code | IEC No. | Size | Cell Voltage | Ampere-Hour Capacity (Ah) | Diameter (mm) | Height (mm) | Weight (g) | 16 Hour Charge Rate Milliamperes | Equivalent 'Dry' Batteries (not rechargeable) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Zinc Carbon | Alkaline Manganese |
| NCC18 | KR/11/45 | AAA | 1.2 | 0.18 | 10.5 | 44.5 | 10.0 | 18 | HP16 | MN2400 |
| NCC12 | KR/15/18 | ½AA | 1.2 | 0.11 | 14.1 | 17.0 | 8.0 | 12 | | |
| NCC24 | | ½AA | 1.2 | 0.24 | 14.3 | 28.1 | 14.0 | 24 | | |
| AN45 | KR/16/29 | ½A | 1.2 | 0.45 | 16.7 | 28.1 | 19.0 | 45 | | |
| AN50 | KR/15/51 | AA | 1.2 | 0.50 | 14.3 | 50.3 | 25.0 | 50 | Penlight HP7 | MN1500 |
| AN60 | KR/17/51 | super AA | 1.2 | 0.60 | 15.6 | 50.0 | 30.0 | 60 | | |
| AN140 | KR/23/43 | RR | 1.2 | 1.40 | 22.6 | 42.6 | 50.0 | 140 | | |
| AN220 | KR/27/50 | C | 1.2 | 2.20 | 26.0 | 49.0 | 70.0 | 220 | HP11 | MN1400 |
| AN260 | KR/35/44 | ½D | 1.2 | 2.60 | 32.5 | 43.7 | 100.0 | 260 | | |
| AN400 | KR/35/62 | D | 1.2 | 4.00 | 32.5 | 61.3 | 140.0 | 400 | HP2 | MN1300 |
| AN450 | R/35/62 | D | 1.2 | 4.50 | 33.8 | 61.0 | 150.0 | 450 | | |
| AN700 | KR/35/92 | F | 1.2 | 7.00 | 33.8 | 91.0 | 225.0 | 700 | | |
| AN1000 | KR/44/91 | super F | 1.2 | 10.00 | 41.5 | 91.0 | 345.0 | 1000 | | |

**Table 1. Some typical cylindrical cells.**

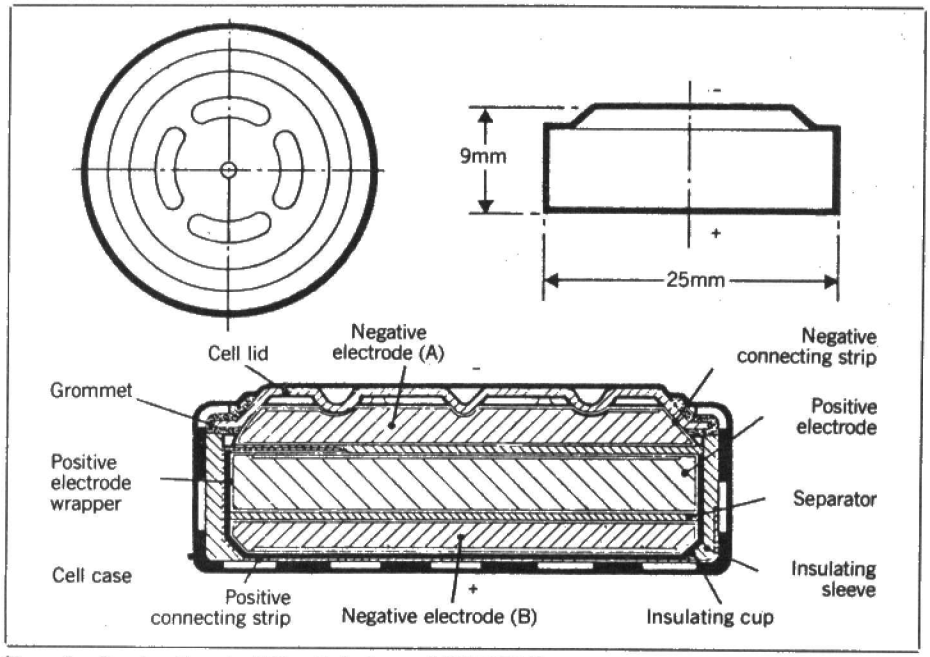
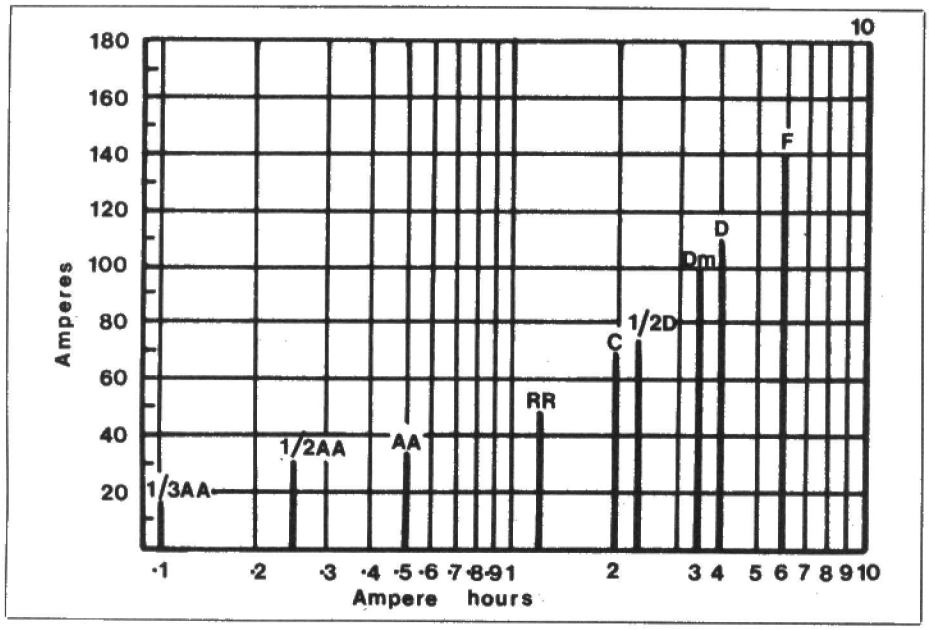



**Figure 3. Construction of a 250 mAh button cell (NCB25DA).**



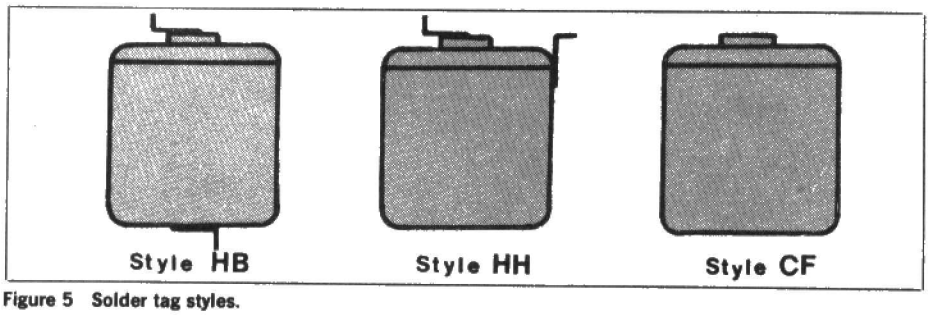




**Figure 5 Solder tag styles.**

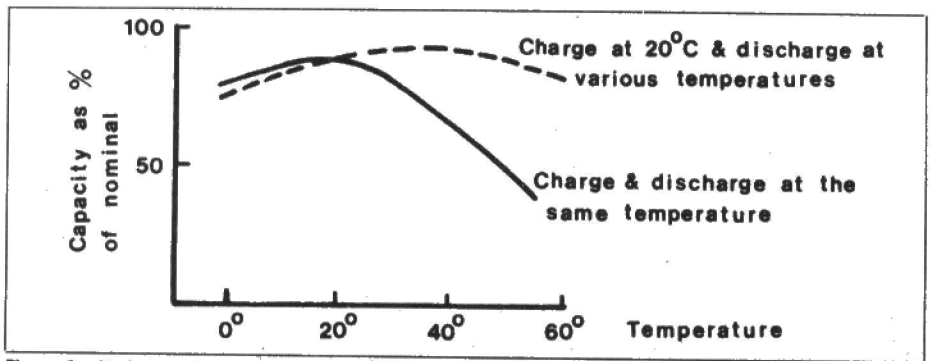

Capacity as % of nominal
Charge at 20°C & discharge at various temperatures
Charge & discharge at the same temperature
Temperature

**Figure 6. Variation of capacity with temperature.**

volts (1.2 x 10) and the capacity is unchanged at 4 Ah.

The charge or discharge currents (or 'rates') of cells and batteries are usually expressed as multiples or sub-multiples of the ONE HOUR or 'C' rate. This standard convention makes for easier comparison between batteries of different sizes.

For instance the C/10 rate will discharge any cell or battery in 10 hours; the C/5 hour rate will discharge it in 5 hours and the 2C rate will discharge in ½ hour. The C/10 rate is 1 A for a 10 Ah battery and 200 mA for a 2 Ah battery.

It is very important to grasp that the charging/discharging cycle has an efficiency coefficient of about 1.5, so that the 'C/10' current would in fact need about 15 hours (10 x 1.5) for a full charge.

It is worth dwelling a little on the cells which have the same dimensions as 'dry' or common non-rechargeable cells. For many purposes e.g. tape recorders, transceivers, torches etc., nickel cadmium cells can take the place of the equivalent battery. They have many advantages. They can give heavier, continuous power if needed, and their voltages are more uniform during discharge. Their rechargeability makes them very economical in use, and many hundreds of recharges can be obtained at a small fraction of a penny each.

Very often nickel cadmium cells are soldered into circuits. This is desirable if high currents are to be taken, or the battery is to be kept on permanent charge in readiness or standby for emergency purposes. Cell manufacturers fit solder tags at no extra cost, and the styles are shown in Figure 5. When ordering cells the designation 'CF', 'HH' or 'HB' should be used. This is easy to remember if associated with the terms 'Contact Free', 'Head-Head', 'Head-Base'. Note that soldering directly on to a cell case could severely damage the cell.

From the point of view of the tolerance of electronic circuits, it is very important to realise that the battery on-charge voltage is higher than the discharge voltage. Thus, a circuit may have to tolerate 1.5 volts per cell on charge at the C/8 rate and a mid-point discharge voltage of 1.25 volts/cell at the C/5 rate.

Sealed (i.e. gas recombining) cells should not be charged in parallel as their very low internal resistances and supressed overcharge voltages can mean that one cell or one row of cells is doing all the work and getting more than its fair share of overcharge current. It is also possible under these parallel conditions for a row of cells to receive very high 'stray' currents from neighbouring rows. Diode protection between rows is sometimes incorporated to reduce this possibility.

## Temperature

A battery is by nature a chemical device and therefore it is affected by temperature in a variety of ways. The lower working limit of the nickel-cadmium system is generally taken to be the freezing point of the potassium hydroxide electrolyte at about -30°C. At low temperatures the charging process becomes more efficient, and for continuous charging under these conditions an upper charge voltage limit of 1.55 volts per cell is often imposed. By this, it is meant the circuits are designed so that as this voltage is approached the charging current will decrease and the upper voltage limit is not exceeded. This will greatly reduce the possibility of gassing under these very efficient charge conditions.

The battery capacity is also affected by temperature and Figure 6 demonstrates this. Note the differences between the two

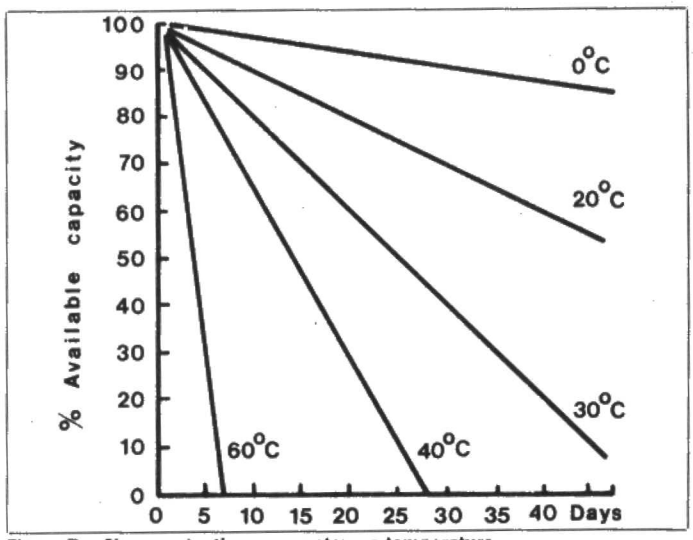



Figure 7. Charge retention versus storage temperature.

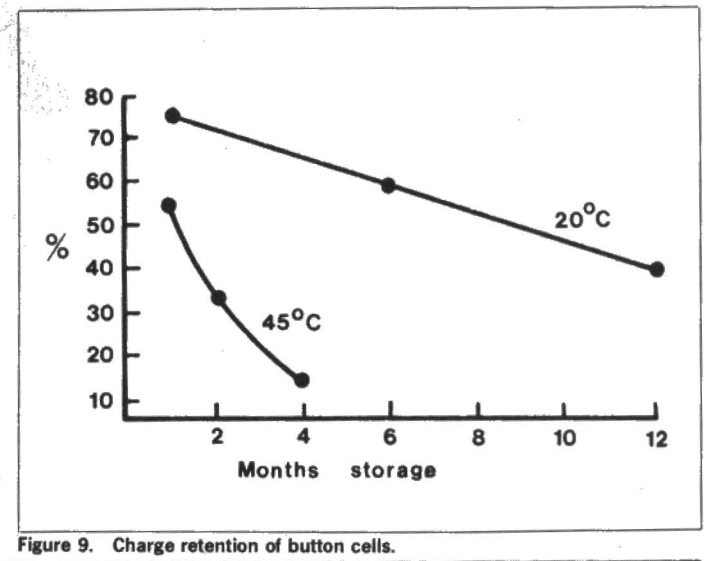



Figure 9. Charge retention of button cells.

curves. Charging is more efficient at low temperatures and less so at high temperatures. These curves highlight this.

Another important aspect of battery temperature is its influence on the retention of charge on standing. Figure 7 demonstrates the marked self-discharge brought about by storing charged cells at elevated temperatures. Compare, however, with the button-cell performance shown on Figure 9.

## Special Cylindrical Cells

When batteries have to be kept on continuous charge under conditions of high temperature, such as in emergency lighting where there are electric lamps, transformers, chokes etc. to generate heat, it is now common practice to use specially formulated cylindrical cells to withstand these arduous conditions and to comply with recent specifications. These batteries need to have an expected life of at least four years in use. (Specification BS 5266 and ICEL 1001.)

## Button Cells

These cells are not fitted with a venting mechanism, and their construction means that they have a higher internal resistance. They are very popular for relatively small current, regular cycling, and infrequent or limited overcharge applications. Their capacities range from 60 mAh to 600 mAh, as shown in Table 2. Although their energy densities are somewhat less than that of cylindricals (70 watt-hours per litre compared with 100 watt-hours per litre), this is often compensated for by the compact way in which they can be stacked to form very convenient battery packs, as illustrated in Figure 8.

A cross-section of a button cell is shown in Figure 3. This is of the 250 mAh size and it will be seen to have three electrodes; one positive sandwiched between two negatives. This is a typical so-called 'D.A.' construction. Other variations are the 'Z.A.' type with only two electrodes and the 'V.A.' with four electrodes. The greater the number of electrodes, the lower the internal resistance for a given Ampere hour capacity (see Table 2).

Button cells are of the 'mass plate' type of construction, in which the electrodes are produced by compressing the active chemical ingredients into metal mesh pockets. The big advantage of these pressed plate cells is that they retain their charge longer when stored (compare figures 7 and 9). This very important property of button cells is often utilised for memory protection in electronic circuits.

Figure 8. A selection of button cell batteries.

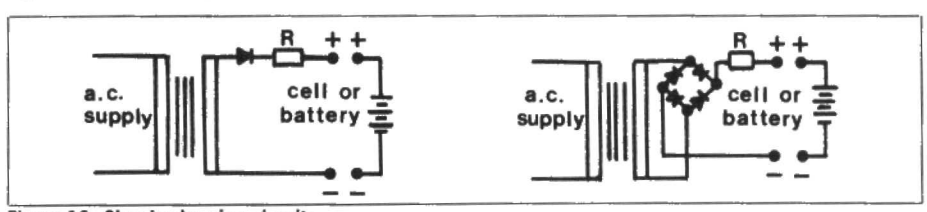



Figure 10. Simple charging circuits.

| | Capacity | Voltage | Maximum Diameter | Maximum Thickness | Approx. Weight | C/10 Charge Rate | Internal Resistance |
|---|---|---|---|---|---|---|---|
| NCB6ZA | 60mAh | 1.2 | 16mm | 6.1mm | 4g | 6mA | 280mΩ |
| NCB11ZA | 110mAh | 1.2 | 23mm | 4.5mm | 6g | 11mA | 140mΩ |
| NCB15ZA | 150mAh | 1.2 | 25mm | 5.5mm | 9g | 15mA | 120mΩ |
| NCB25ZA | 250mAh | 1.2 | 25mm | 9.0mm | 13g | 25mA | 100mΩ |
| NCB25DA | 250mAh | 1.2 | 25mm | 9.0mm | 13.5g | 25mA | 70mΩ |
| NCB60ZA | 600mAh | 1.2 | 35mm | 10.0mm | 30.0g | 60mA | 70mΩ |
| NCB60VA | 600mAh | 1.2 | 35mm | 10.0mm | 30.5g | 60mA | 30mΩ |

Table 2. Some typical button cells.

Continuous charging of button cells is possible at normal temperatures, but it is necessary to limit the charge current to C/100. Thus, for the 250 mAh cell or battery, the maximum 'trickle' current should be 2.5 mA.

As with other cells, solder joints must not be made directly on to the cell cases, as internal plastic insulators could be damaged. Manufacturers supply cells and batteries with solder tags as requested. Certain packs, for memory protection, are often supplied with tags suitable for fixing directly to PC boards.

## Charging

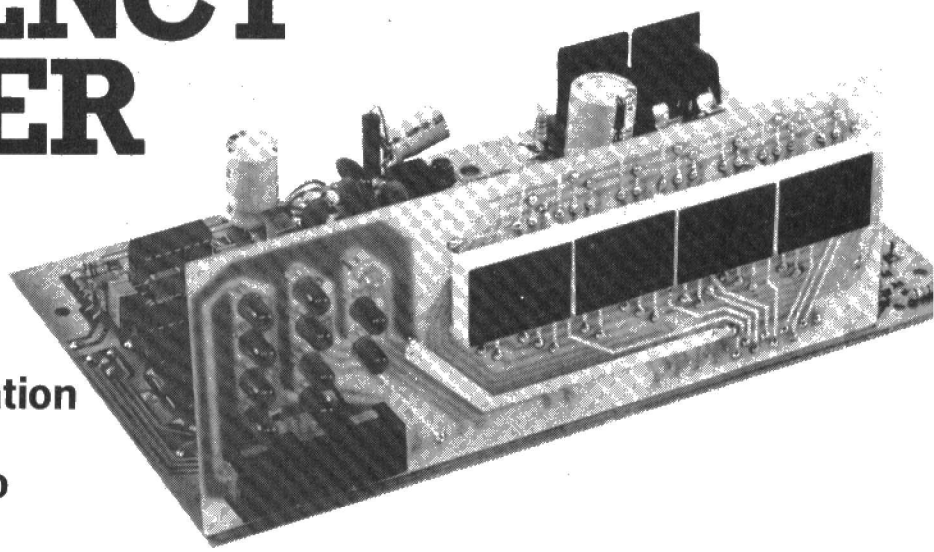
For most purposes a 'constant-current' charge system is used for sealed cells. Figure 10 gives a couple of simple circuits suitable for this purpose. For a satisfactory constant current it is recommended that the resistances marked 'R' drop a voltage about equal to that of the battery being charged.

Other types include circuits for charging from vehicle batteries, solar cells and transistorised sources, and there are many techniques employed for controlling such refinements as fast charging, and correcting for extremes of environmental conditions.

Simple, well designed, and convenient chargers are readily available on the retail market, to accept and charge cells and batteries for domestic items such as torches, tape recorders, and toys etc.

# THE 8-DIGIT FREQUENCY COUNTER

*by Chris Barlow*



- ★ **Ranges from 100Hz to 500MHz**
- ★ **Mains or 12V DC operation**
- ★ **Clear 8-digit display**
- ★ **Easy to build – only two interconnecting wires**

This frequency counter offers a superior specification for the first time in kit form. The design is based on the Intersil ICM7216D, and includes electronically switched ranges for greater reliability and ease of construction. Provision has been made for possible future extensions, so this kit can be considered truly flexible.

The integrated circuits used are of an extremely advanced and sophisticated design, including CMOS, ECL, and Schottky TTL. The display uses multiplexed large red 7-segment LEDs for easy viewing. The functions and ranges are selected by computer-style key switches, and displayed on rows of different coloured LEDs. The input is a single BNC socket, and is switched automatically to the correct input amplifier. The counter will run off either an internal or an external reference oscillator, of either 1MHz or 10MHz (programmable). The power supplies are fuse protected on both DC and AC inputs.

## The Frequency Counter

IC1 (ICM7216D) has multiplexed inputs for function and range select. It also has its own internal reference

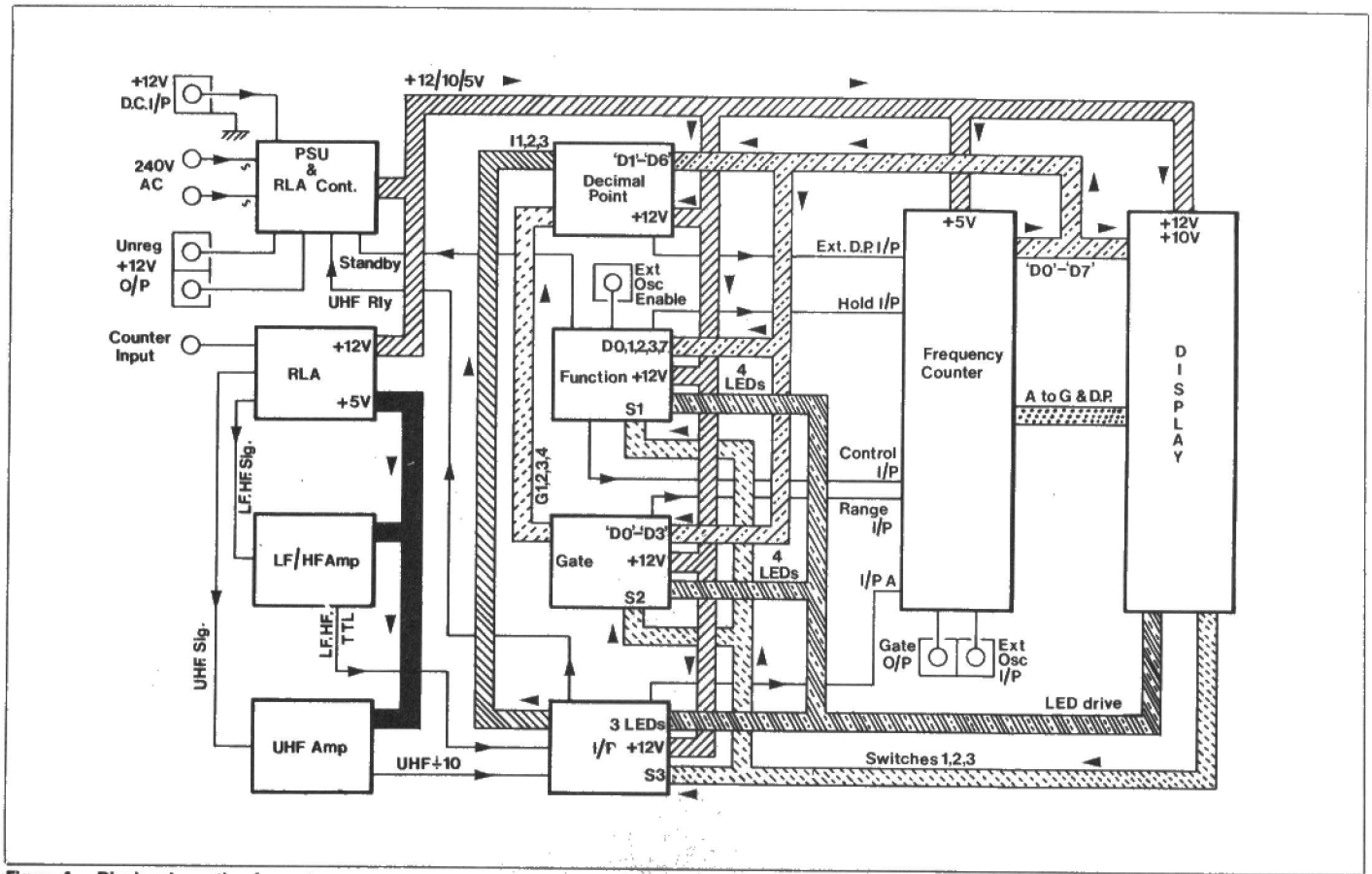



**Figure 1. Block schematic of counter.**

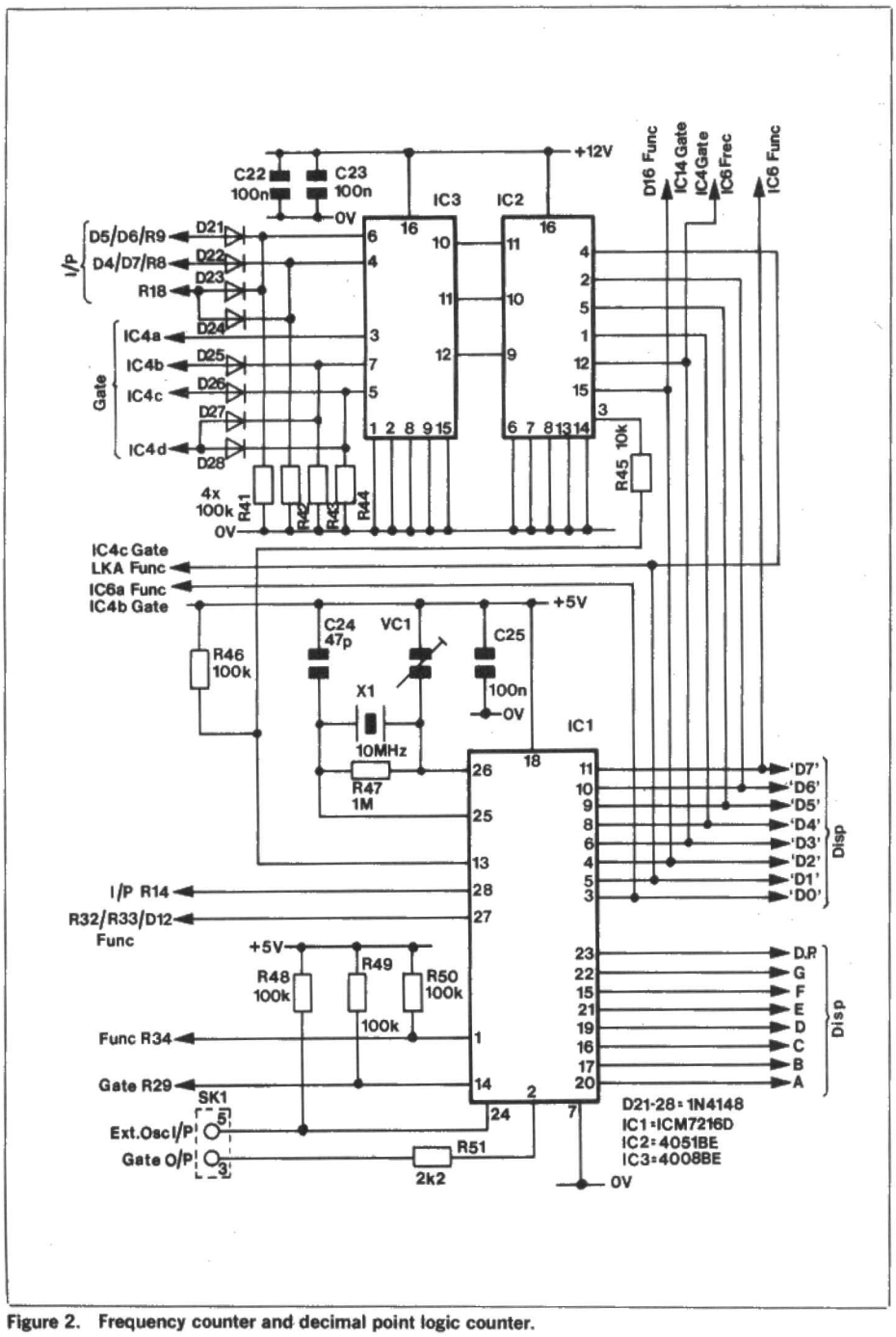
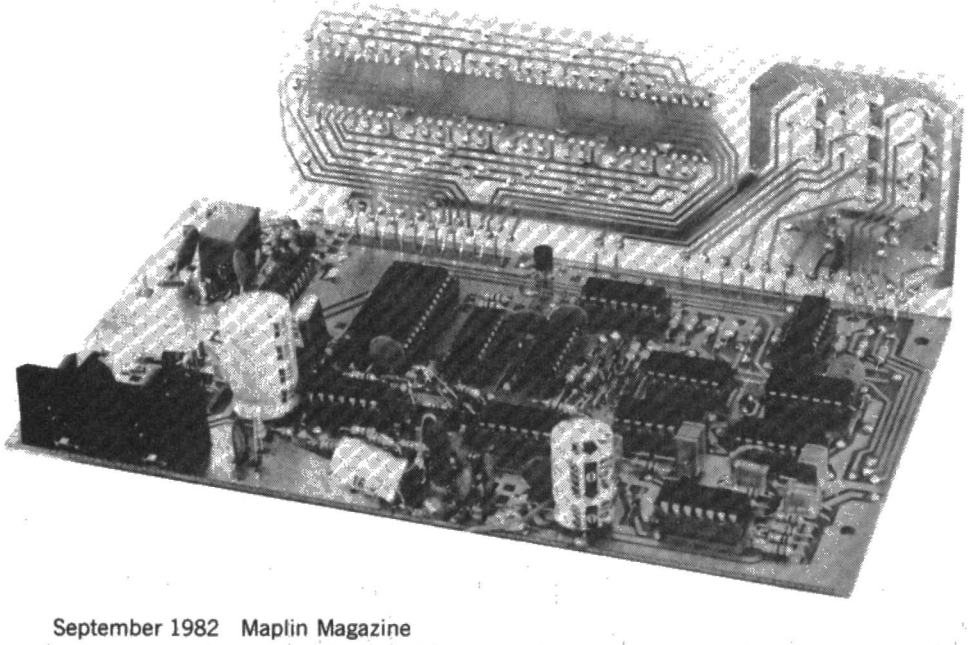



**Figure 2. Frequency counter and decimal point logic counter.**



oscillator, as well as provision for an external oscillator input (pin 24). Its internal oscillator is controlled by either a 10 MHz or a 1 MHz crystal. A 10 MHz crystal is supplied with the kit. Please note that if you wish to use the 1 MHz option, LKA on the PCB must be fitted. The crystal frequency is set by VC1. The setting of VC1 will determine the accuracy of the displayed frequency, and care should be taken in making this adjustment. IC1 provides the digit and segment drive for the 8-digit 7-segment displays. The digit drive multiplex signal is also used in the function and gate time selects circuits, to control the function and range inputs of IC1. Pin 2 of IC1 provides a gated signal output, which is fed to pin 3 of SK1, for possible future expansion to the system.

## The Decimal Point

ICs 2 and 3 (CMOS 4051 and 4008) control the position of the decimal point. This is calculated by looking at the input range and gate time settings. The decimal point occurs at the transitional point between MHz and 100s kHz, except for the 10s gate time on L.F. range, where the decimal point occurs between Hz and tenths of Hz.

## The Gate Time Function

This uses the CMOS 4093 (IC11) and 4017 (IC5) to select the gate times. The 4017 controls the CMOS bilateral switch CMOS 4016 (IC4). This selects the appropriate multiplex data line, which controls the range input (pin 14 of IC1). ICs 9 and 10 are the LED drivers for the four LEDs used in the display.

## The Function Circuit

This is almost identical in operation to the Gate Time Circuit, but the multiplex data selected is fed to the control pin of IC1 (pin 1). In addition, the function circuit feeds signals to the input select, gate time select, and +10V control circuits. This disables the input select and gate time select in every mode except COUNT, also the +10V control is shut down in the DISPLAY OFF mode. A hold signal is generated in the function circuit which is fed to pin 27 of IC1, so that the frequency displayed can be stored for as long as is required. The display LEDs are driven by IC10 (CMOS 4049).

## The Input Range Select Circuit

This functions similarly to the previous two, but features the control of Schottky TTL gates, which select either direct frequency, divide by ten, or divide by a hundred ranges. This is necessary because the maximum frequency that IC1 can handle is 10 MHz, therefore, for HF and UHF, division of the input signal is necessary. IC13 is the divide by ten chip used for HF and UHF ranges. In the UHF mode the

prescaler IC14 divides by ten, which is then fed into IC13, making a total division of one hundred. IC9 drives the display LEDs.

## The UHF Input Amplifier/Prescaler

The UHF input stage uses a ZTX326 (TR3) broad band, high frequency amplifier in the common base mode. The UHF signal is fed to TR3 via the input relay circuit. It is then fed to the input pins (15 and 16) of IC14. The IC divides the signal by a factor of ten, and the signal is then fed to the input select circuit.

## The LF/HF Amplifier

The input to the amplifier is a FET source follower, TR5, to provide a high input impedance. This feeds the signal into pin 5 of IC16, a three stage broadband amplifier. The output on pin 15 is a 1V peak-to-peak signal, which is fed to the base of TR4. This then converts the signal into a TTL switching level, which is fed to pin 1 of IC15. This provides a clean switching waveform to drive the input select circuit. The output is on pin 8.

## Power Supply and Relay Control

This consists of a standard transformer/bridge rectifier network, which provides an unregulated 12V supply for the CMOS circuits. REG 1 is a +5V, ½A regulator, and has a 1N4148 diode in its common return to increase the output voltage to +5.6V. This gives a brighter display and more reliable TTL switching. The 10V controlled output feeds the display LEDs on GATE TIME and INPUT ranges. The 10V is shut down in the DISPLAY BLANK mode, by IC11 controlling TR1. The relay RLA is controlled by TR2/IC9, and is active when UHF is selected. The relay controls the voltage and signal feed to either the LF/HF amplifier, or the UHF input amplifier/prescaler.

## The Input Protection Circuit

This provides DC isolation to 500V, and AC protection up to a 5V peak-to-peak signal. This is achieved with limiting diodes and DC isolation capacitors on the input.

## Construction

This project has been designed to fit into the aluminium instrument case XY45Y. Holes have to be drilled for the transformer, regulator, mains input socket, and fuse, as they are all mounted on the back of the box. Holes also have to be drilled to allow access to the PCB mounted power connector and auxiliary socket. The front of the case requires holes drilling for the BNC input socket, the three key switches, the

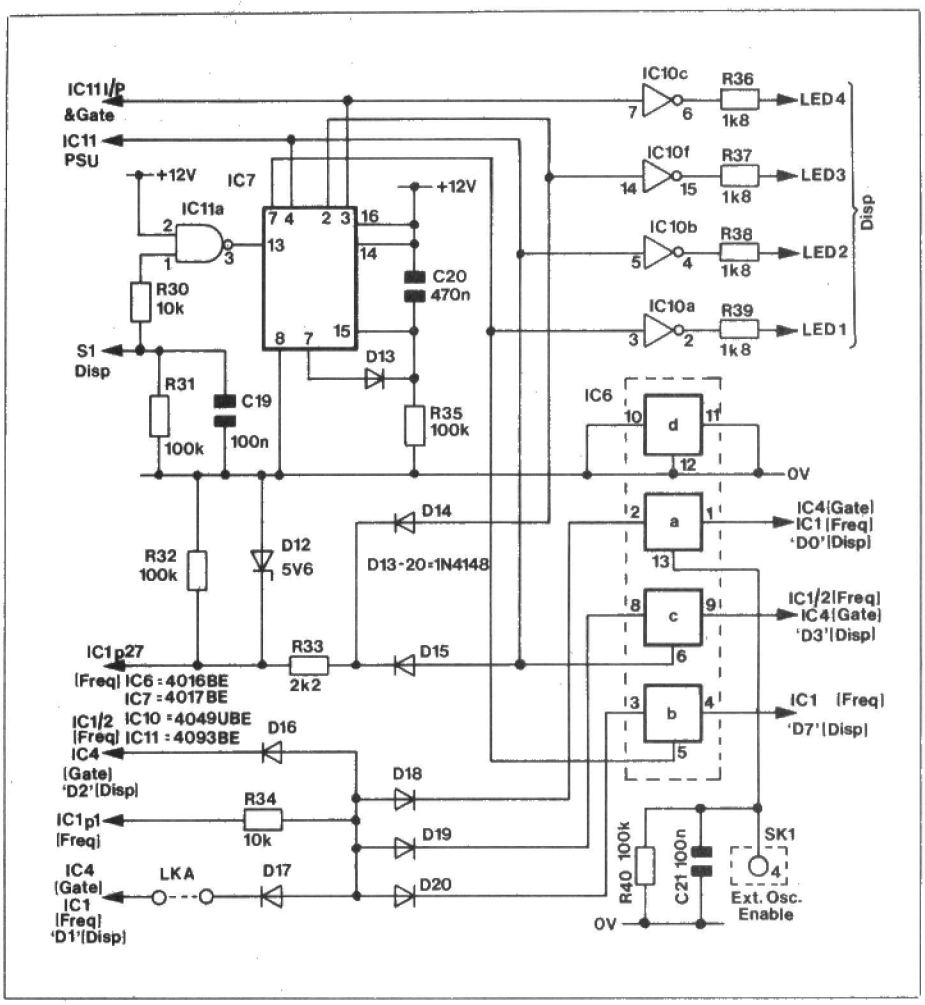



**Figure 3. Function select circuit.**

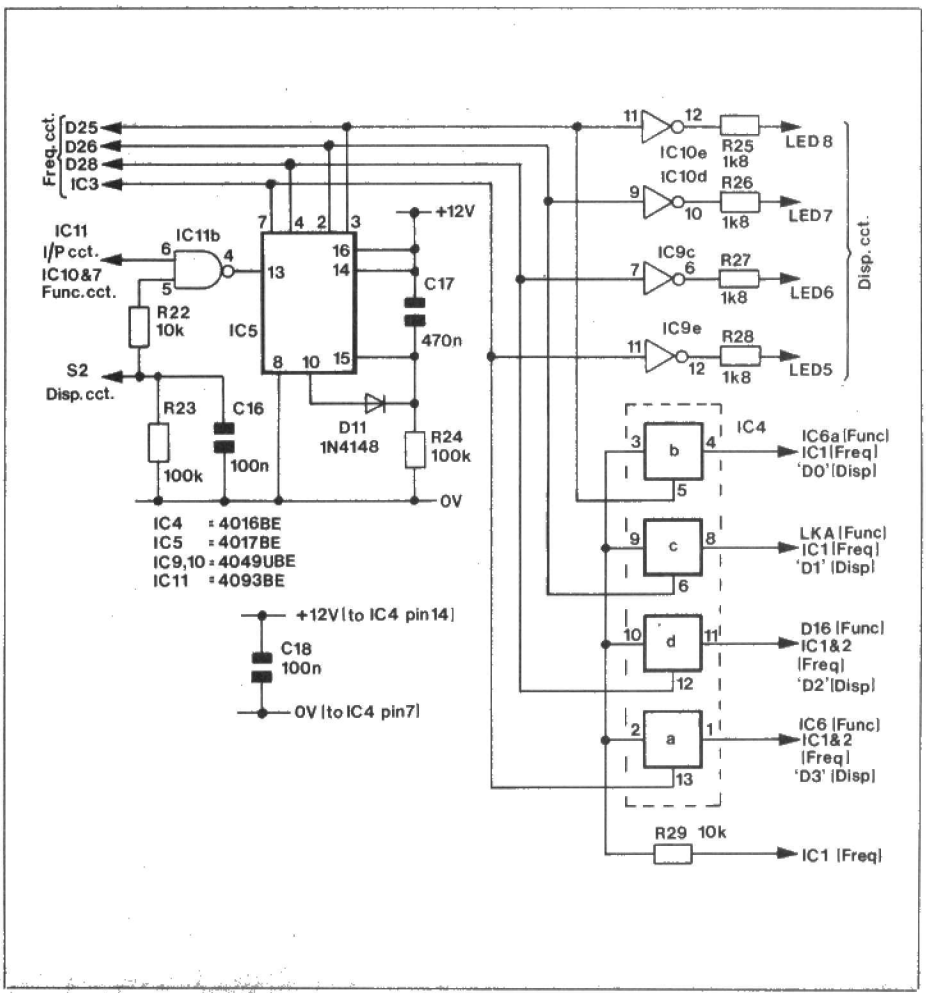



**Figure 4. Gate time circuit.**

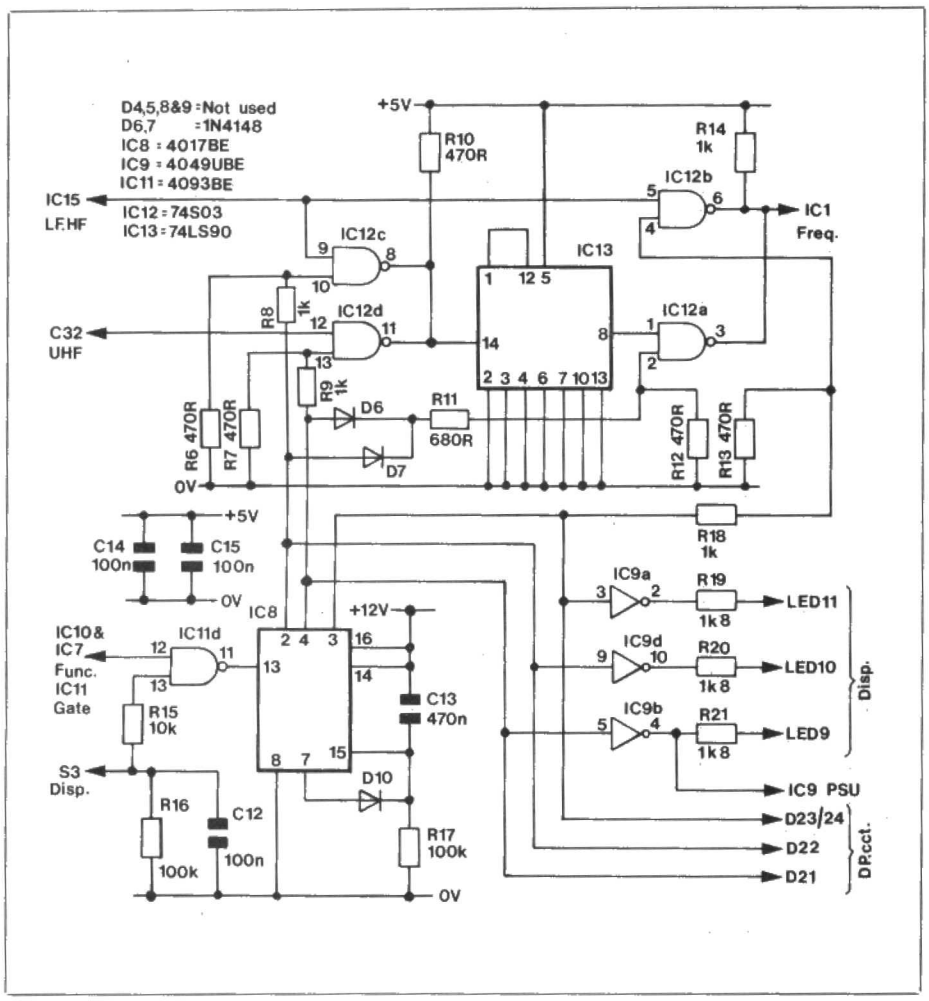



**Figure 5. Input select circuit.**

three rows of LEDs, and a rectangular window needs cutting for the display. The holes are already provided on the bottom of the box to fit the main PCB on ⅛" 6BA spacers. The CMOS ICs are all provided with sockets, and care should be taken when handling these devices.

# The Main PCB

First, fit all track pins, making sure that they are all soldered on both sides. Then insert and solder the Vero pins into their correct positions, and fit all resistors and diodes, including BR1, checking for correct polarity on all the diodes.

Fit the two PCB mounting connectors and the fuse clips. Fit all capacitors, including VC1. Make sure that all the electrolytics and tantalums are correctly polarised. Fit the relay RLA and all IC sockets. These are *only* provided for CMOS ICs. Sockets should *not* be fitted to the ECL and TTL devices, as these can operate at frequencies that make the use of sockets undesirable. Fit the transistors, including the input FET, and solder the regulator into a position enabling it to be bolted to the back panel when the PCB is fitted into the case. Fit the crystal, taking care not to overheat this component. Clean the underside of the PCB, and check soldering for possible dry joints etc.

# The Display PCB

Fit all track pins. Fit all 7-segment displays, ensuring correct orientation with markings towards the bottom of the board. Fit all display LEDs, and then the three push switches as shown in Figure 10. Check your soldering!

# Fitting the Display PCB to the Main Board

The display PCB must be mounted at an angle of 90 degrees to the main board, and the bottom edge must run parallel to the front edge of the main PCB. Solder the inter-PCB connecting links to the main board.

All CMOS chips with the exception of IC1 should now be fitted. Normal CMOS precautions should be observed. Fit the BNC socket and glue the red filter to the front panel (as shown in Figure 11). The main PCB should now be tested (see the setting up procedure). After testing, mount the PCB with spacers (Figure 11), and bolt the regulator (using the mica washer), the mains transformer, the fuseholder, and the mains input socket to the back panel (Figure 12), and wire up as shown. Fit the capacitors to the back of the BNC socket as shown in Figure 11.

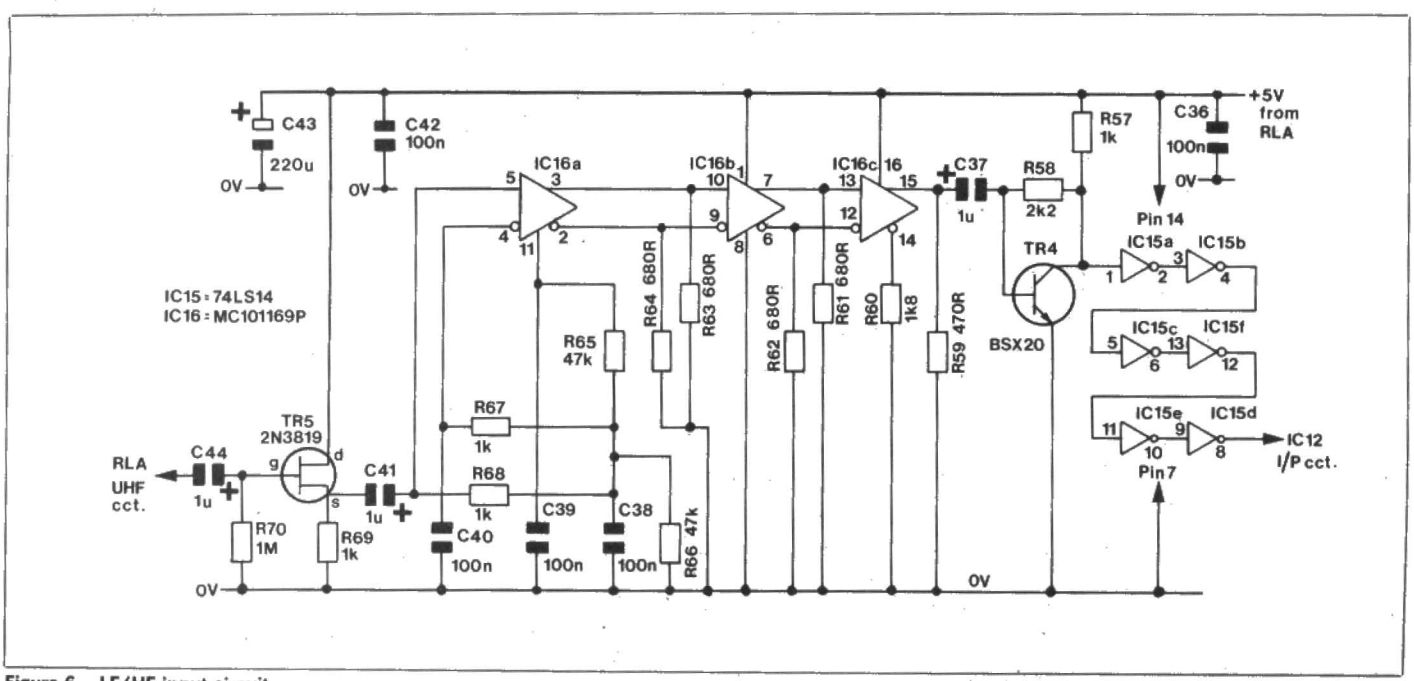



**Figure 6. LF/HF input circuit.**

# Setting Up

Before fitting into the case, the voltage regulator and CMOS control logic can be tested. A 12V DC supply is needed. This can be a battery, C.B. power supply, or similar. Fit a meter capable of reading 1A fsd across the PCB fuseclips, with the negative lead on the side of the fuseclip which connects to the anode of D3. Fit a temporary heatsink (e.g. a croc clip) to the metal tab of the regulator. Connect the 12V supply via the PCB mounted power input socket. A current of no more than 200mA should be observed. If there is more than 200ma, disconnect immediately and check the construction. If there is zero current, you may have incorrect polarity on the power supply. If all is correct the bottom LED in each row should be lit, but none of the 7-segment displays. Press each switch in turn, and check that the LEDs illuminate in sequence. The function should be kept in COUNT mode whilst checking the ranges. When the function is in any mode other than COUNT, the other two switches should have no effect. In 'DISPLAY OFF' mode, the range LEDs will extinguish. Remove the meter and replace the fuse FS2. The regulator output should now be measured, using a voltmeter connected with the negative lead to 0V, and the positive lead to test point 1. A reading of approximately 5.5V should be obtained. Ensure that there is no DC present on pins 1, 13, and 14 of IC1 holder, and that when the function is on HOLD, there should not be more than 6V on pin 27. Remove the power and carefully insert IC1. Re-apply the power and a display should be visible, as

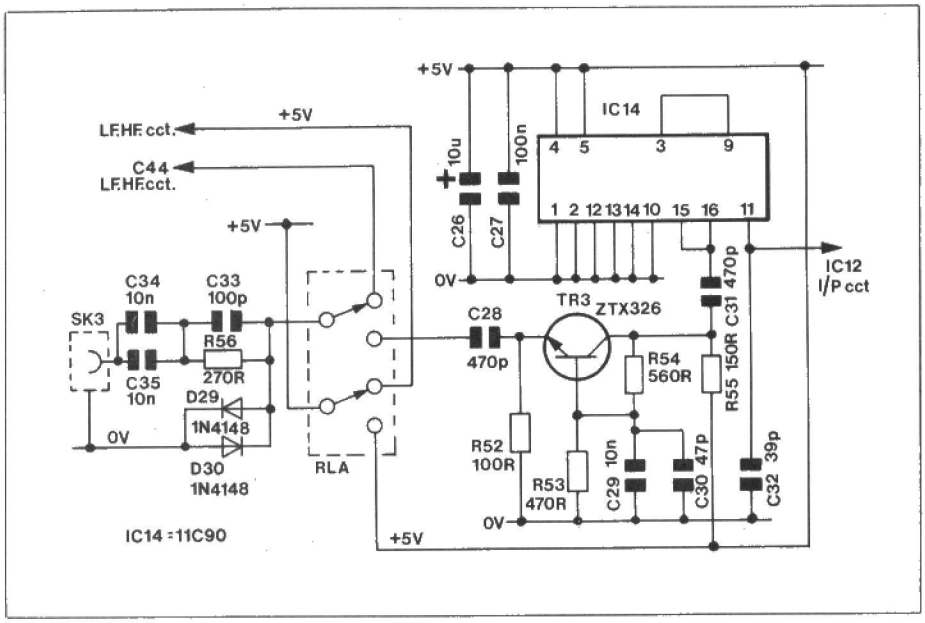
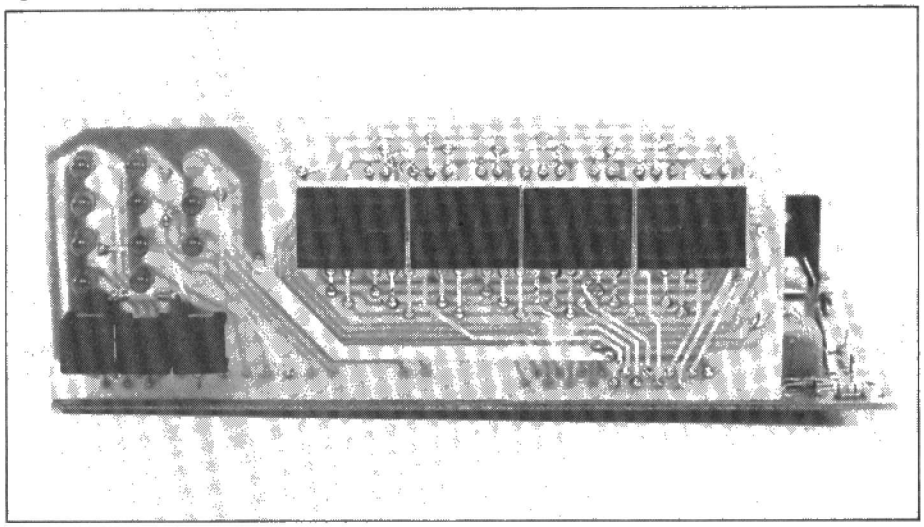



Figure 7. UHF input and relay circuit.



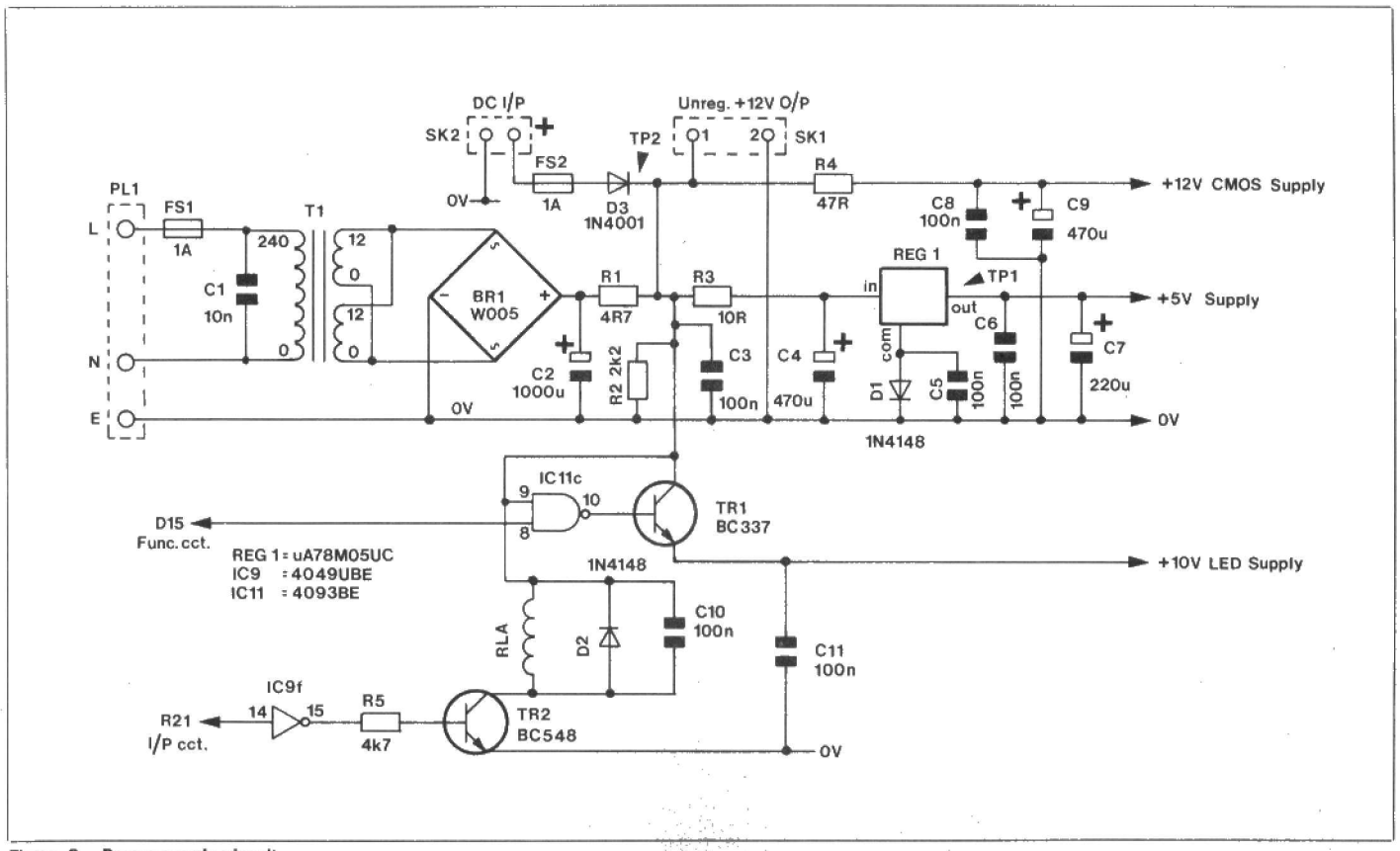
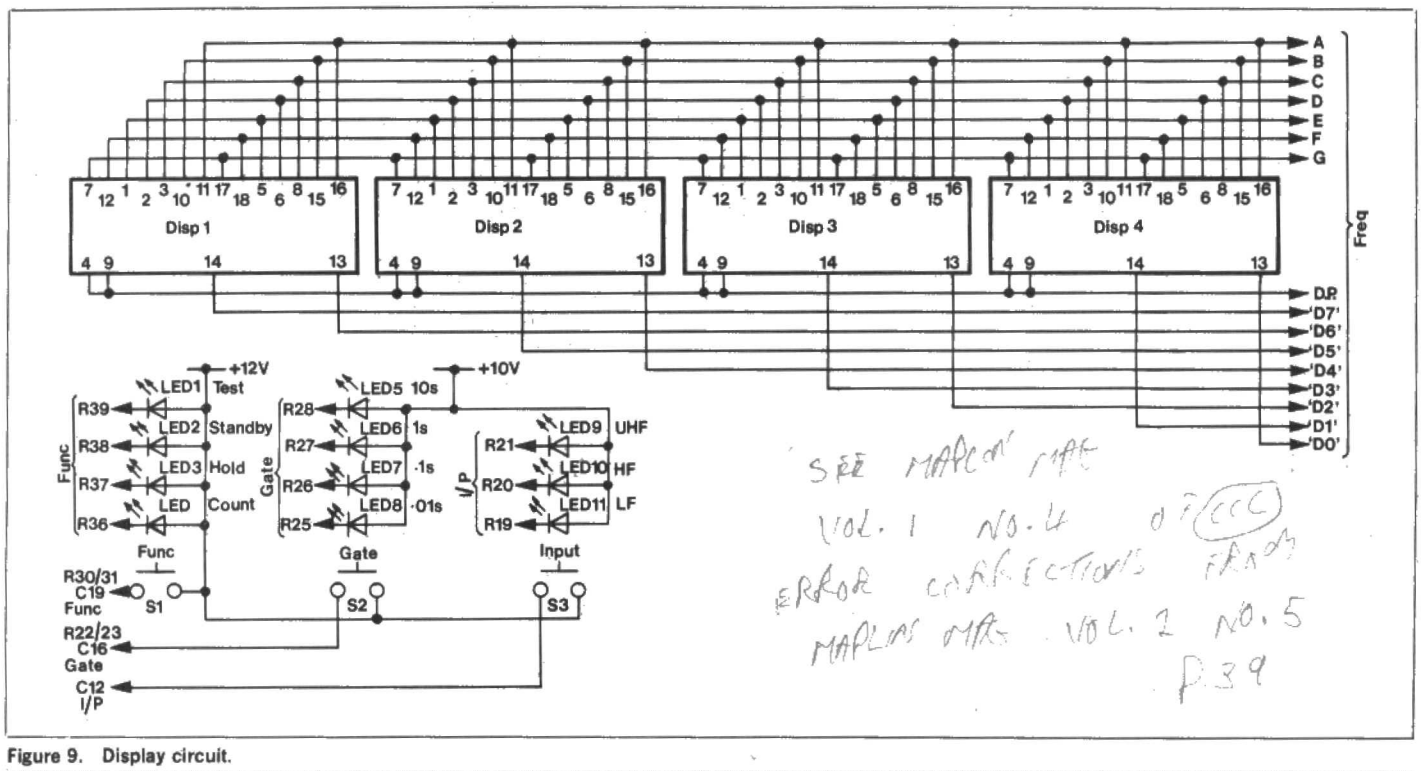



Figure 8. Power supply circuit.




SEE MAPLIN MAG VOL. 1 NO. 4 OF (CCC) ERROR CORRECTIONS FROM MAPLIN MAG VOL. 2 NO. 5 P.39

**Figure 9. Display circuit.**

# MAIN PARTS LIST

Resistors: All ¼W 5% Carbon unless specified.

| | | | |
|---|---|---|---|
| R1 | 4R7(½W) | | (S4R7) |
| R2,33,51,58 | 2k2 | ( 4 off) | (M2K2) |
| R3 | 10R (3W wirewound) | | (W10R) |
| R4 | 47R(½W) | | (S47R) |
| R5 | 4k7 | | (M4K7) |
| R6,7,10,12,13, 53,59 | 470R | ( 7 off) | (M470R) |
| R15,22,29,30, 34,45 | 10k | ( 7 off) | (M10K) |
| R8,9,14,18,57, 67,68,69 | 1k | ( 8 off) | (M1K) |
| R16,17,23,24,31, 32,35,40-44,46, 48-50 | 100k | (16 off) | (M100K) |
| R19-21,25-28, 36-39,60 | 1k8 | (12 off) | (M1K8) |
| R47,70 | 1M | ( 2 off) | (M1M) |
| R52 | 100R | | (M100R) |
| R54 | 560R | | (M560R) |
| R55 | 150R | | (M150R) |
| R56 | 270R(½W) | | (S270R) |
| R11,61-64 | 680R | ( 5 off) | (M680R) |
| R65,66 | 47k | ( 2 off) | (M47K) |
| Capacitors | | | |
| C1 | 10nF suppression Cap. | | (FF53H) |
| C2 | 1000uF 25V P.C. Electrolytic | | (FF18U) |
| C3,5,6,8,10,11, 14,15,18,21-23, 25,27,36,38-40, 42 | 100nF disc ceramic | (19 off) | (BX03D) |
| C4,9 | 470uF 25V P.C. Electrolytic | ( 2 off) | (FF16S) |
| C7,43 | 220uF 16V P.C. Electrolytic | ( 2 off) | (FF13P) |
| C12,16,19 | 100nF Polycarbonate | ( 3 off) | (WW41U) |
| C13,17,20 | 470nF Polycarbonate | ( 3 off) | (WW49D) |
| C24 | 47pF Silver Mica | | (WX09K) |
| C26 | 10uF 16V Tantalum | | (WW68Y) |
| C28,31 | 470pF Ceramic | ( 2 off) | (WX64U) |
| C29 | 10nF Disc Ceramic | | (BX00A) |
| C30 | 47pF Ceramic | | (WX52G) |
| C32 | 39pF Ceramic | | (WX51F) |
| C33 | 100pF Ceramic | | (WX56L) |
| C34,35 | 10nF 500V H.V. disc | ( 2 off) | (BX15R) |
| C37,41,44 | 1uF 35V Tantalum | ( 3 off) | (WW60Q) |
| VC1 | Trimmer 65pF | | (WL72P) |
| Semiconductors | | | |
| D1,2,6,7,10,11, 13-30 inc. | 1N4148 | (18 off) | (QL80B) |
| D3 | 1N4001 | | (QL73Q) |
| D12 | BZY88C5V6 | | (QH08J) |
| TR1 | BC337 | | (QB68Y) |
| TR2 | BC548 | | (QB73Q) |
| TR3 | ZTX326 | | (QL54J) |
| TR4 | BSX20 | | (QF32K) |
| TR5 | 2N3819 | | (QR36P) |
| REG.1. | uA78M05uC | | (QL28F) |
| IC1 | ICM7216D | | (YY94C) |
| IC2 | 4051BE | | (QW34M) |
| IC3 | 4008BE | | (QW14Q) |
| IC4,6 | 4016BE | ( 2 off) | (QX08J) |
| IC5,7,8 | 4017BE | ( 3 off) | (QX09K) |
| IC9,10 | 4049UBE | ( 2 off) | (QX21X) |
| IC11 | 4093BE | | (QW53H) |
| IC12 | 74S03 | | (QY24B) |
| IC13 | 74LS90 | | (YF38R) |
| IC14 | 11C90 | | (QY18U) |
| IC15 | 74LS14 | | (YF12N) |
| IC16 | MC101169P | | (QY23A) |
| BR1 | W005 | | (QL37S) |
| Miscellaneous | | | |
| X1 | 10MHz crystal | | (FY78K) |
| RLA | Ultra-min Relay DPDT | | (YX95D) |
| SK1 | P.C. Mtg. Power Skt. | | (RK37S) |
| SK2 | P.C. Din SKT 5-Pin 'A' | | (YX91Y) |
| FS2 | 20mm Fuse 1A | | (WR03D) |
| | Fuse clip | ( 2 off) | (WH49D) |
| | 28 Pin Dil Skt | | (BL21X) |
| | 14 Pin Dil Skt | ( 3 off) | (BL18U) |
| | 16 Pin Dil Skt | ( 7 off) | (BL19V) |
| | Veropin 2141 | ( 1 Pkt) | (FL21X) |
| | Track Pin | ( 2 Pkt) | (FL82D) |
| | P.C.B. | | (GB02C) |
| | Screw 6BAx½" | ( 1 Pkt) | (BF06G) |
| | 6BA Nut | ( 1 Pkt) | (BF18U) |
| | 6BA Washer | ( 1 Pkt) | (BF22Y) |
| | 6BA Spacer x ⅛" | ( 1 Pkt) | (FW33L) |
| | Kit (P) Plas | | (WR23A) |

# DISPLAY PARTS LIST

| | | | |
|---|---|---|---|
| Disp 1-4 | 'DD' Display Type C | ( 4 off) | (BY68Y) |
| S1,2,3 | Click Key Black | ( 3 off) | (HY34M) |
| LED 1-4, 10 | Red LED | ( 5 off) | (WL27E) |
| LED 5-8, 11 | Green LED | ( 5 off) | (WL28F) |
| LED 9 | Yellow LED | | (WL30 H) |
| | Track Pin | ( 2 Pkt) | (FL82D) |
| | P.C.B. | | (GB03D) |

# ADDITIONAL ITEMS LIST

| | | |
|---|---|---|
| T1 | Transformer 12V 500mA | (YK28F) |
| FS1 | 20mm Fuse 1A | (WR03D) |
| | Chassis Fuseholder | (RX96E) |
| PL1 | Euro Conn. Lead set | (BW99H) |
| SK3 | BNC Skt | (HH18U) |
| | Case | (XY45Y) |
| | Filter Red | (FR34M) |
| | BNC Earth Tag | (QY22Y) |
| | Freq. C. Front Panel | (RK39N) |
| | Long Power Plug | (HH61R) |
| | BA Mains Plug | (RW67X) |
| | Mains Fuse 3A | (HQ32K) |

A complete kit of parts is available for this project including an attractive printed and punched adhesive aluminium front panel.
**Order As LW79L (Frequency Counter Kit) Price £85.00**

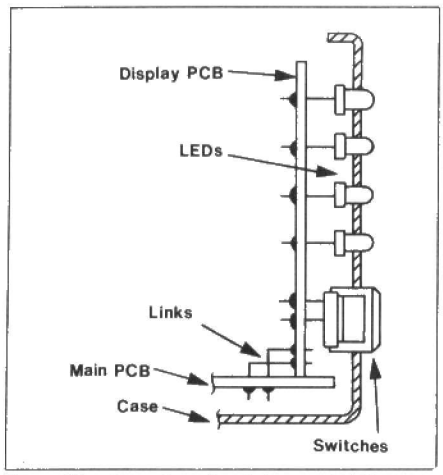



Figure 10. Mounting of switches and LEDs.

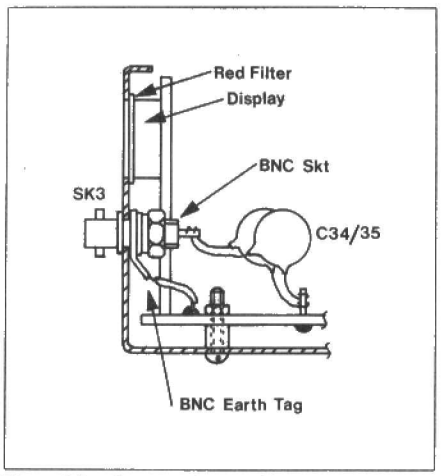



Figure 11. Suggested assembly.

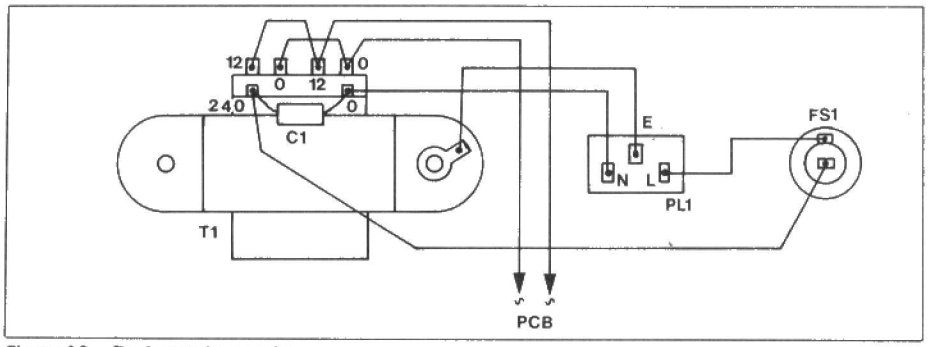



Figure 12. Back panel assembly.

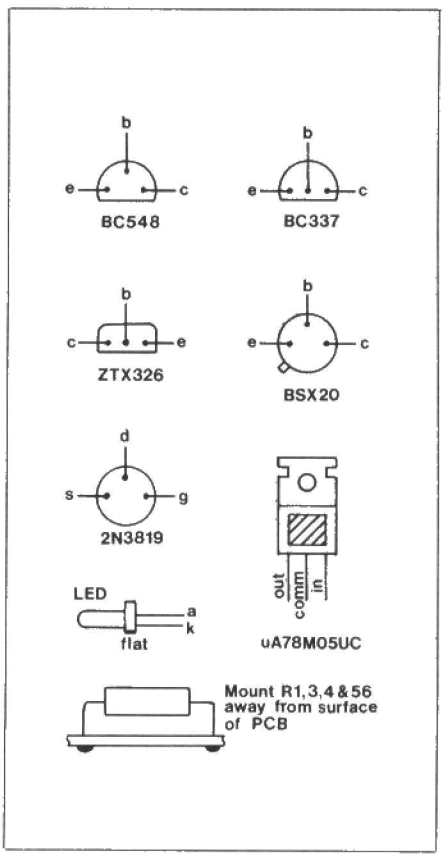



Figure 14. Pin designations.

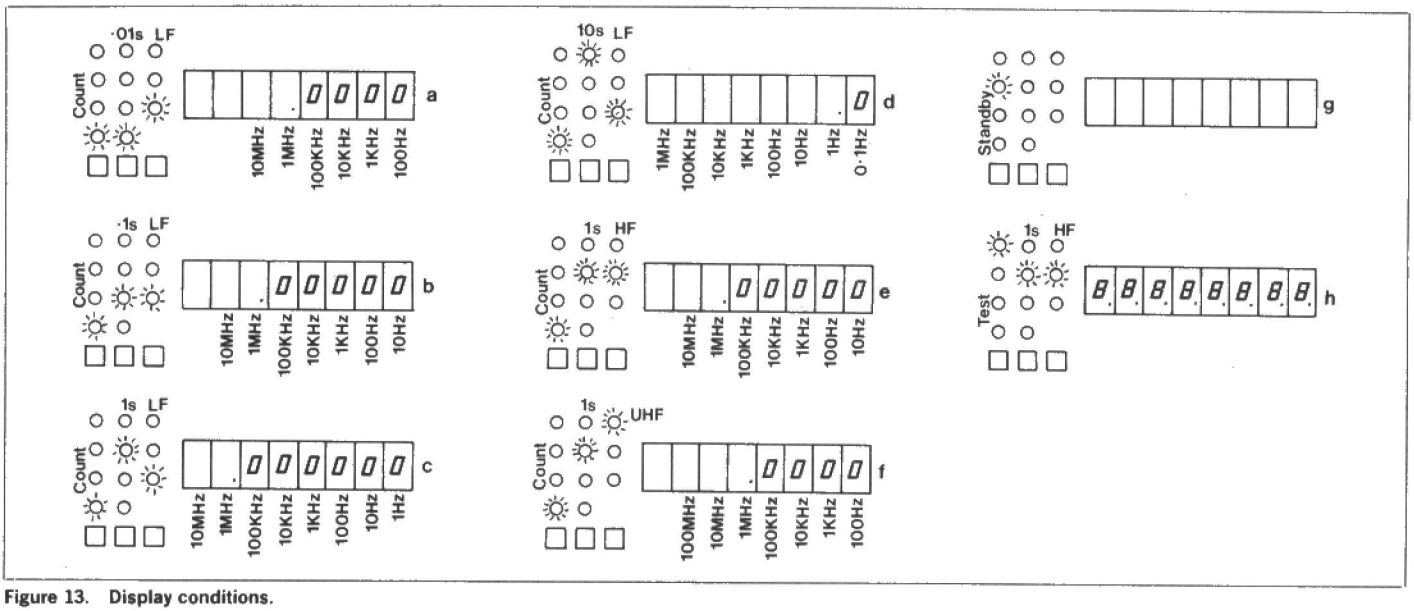



Figure 13. Display conditions.

shown in Figure 13a. Switch through the ranges, and check that the display varies as in Figures 13b to 13h. At this stage the counter is fully working, and frequency measurement is possible.

When the function is in the TEST position, no more than 320mA should be drawn from the DC supply. The counter should now be assembled as described in Construction Details, and the AC feed wires should be connected to the PCB.

Plug in the mains, and check that all functions are correct as before. A DC voltage measurement should be taken between 0V and TP2. Not more than +15V, and not less than +11V should be present. The trimming capacitor VC1 should be adjusted for correct reading using an input of known frequency.■


## NEW MAPLIN CATALOGUE

The new Maplin Catalogue for 1983 will be published in November 1982. Expanded to 384 pages, the new catalogue contains hundreds of interesting new lines, an enlarged Computing section and a new section titled Communications.

As always, the whole catalogue is completely rewritten and updated where necessary, and forms a superb reference book for the home constructor. This is the only book every home constructor must have. And it's an incredible best-seller. Our 1981 catalogue has now sold well over 160,000 copies. Our new catalogue will be available at the Electronics Hobbies Fair at the Alexandra Pavilion from 18th to 21st November; it will be available in all branches of W. H. Smith by 19th November and mail-ordered copies will be posted out on the 30th November.

Prices are as follows:

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| Electronics Hobbies Fair | £1 |
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# STARTING POINT

*by R. Penfold*

**Introducing the fundamentals of electronics for the constructor.**

## Inductance

An inductor is one of the most simple types of electronic component, and even a short piece of wire acts as an inductor having a very low value. However, most practical inductors are in the form of a coil of wire wound on a special core that gives a high value for the length of wire used. In theory an inductor is assumed to have zero resistance, but practical inductors do, of course, have significant resistances. It is for this reason that special cores which enable a minimal length of wire to be used for a given inductance are an asset, since the shorter the length of wire used, the lower the resistance of the component. Even so, high value R.F. inductors (or "chokes" as they are often called) are usually wound using a considerable length of thin wire, and consequently have a resistance of a few tens or even hundreds of ohms.

Although an inductor allows a D.C. signal to pass readily, the situation is very different if an inductor is fed with an A.C. signal. As we saw in an earlier "Starting Point" article, a magnetic field is generated around a piece of wire if it is fed with an electric current, and an electric current is generated in a wire if it is placed in a magnetic field of varying strength. These two effects are used in a transformer to couple an A.C. signal from one winding to another.

With a simple inductor fed with an A.C. signal it is not the effect of the generated magnetic field on another inductor that is of importance, it is the effect of this magnetic field on the inductor which receives the signal that is of interest. One might reasonably expect the magnetic field produced to either generate a signal within the inductor that aids the input signal, or opposes it, and in practice the polarity of the magnetic field is such that it opposes the input signal.

If a voltage source is applied to an inductor the current flow gradually increases, and (for a theoretically perfect inductor) is only limited ultimately by maximum current that the signal source can provide. Inductance is specified in "henrys", and a change in current flow of one amp per second is produced when one volt is applied to a one henry inductance. As one henry is an extremely high inductance value most practical inductors, have their value specified in millihenrys (mH) or microhenrys (uH). A millihenry is one thousandth of a henry, and a microhenry is one millionth of a henry.

Like a capacitor an inductor has reactance, and it is this property that is exploited in electronic circuits, and it is unusual for an inductor to be used in a timing circuit as capacitors are usually much more convenient in such applications. It is important to realise that capacitive inductance and inductive reactance are very different. The reactance of a capacitor falls as the input frequency is increased, whereas the reactance of an inductor increases as the frequency of the applied signal is raised. As a capacitor has a very high resistance and an inductor has an extremely low resistance, these two types of component are complementary to each other rather than true alternatives, and are definitely not direct substitutes for one another.

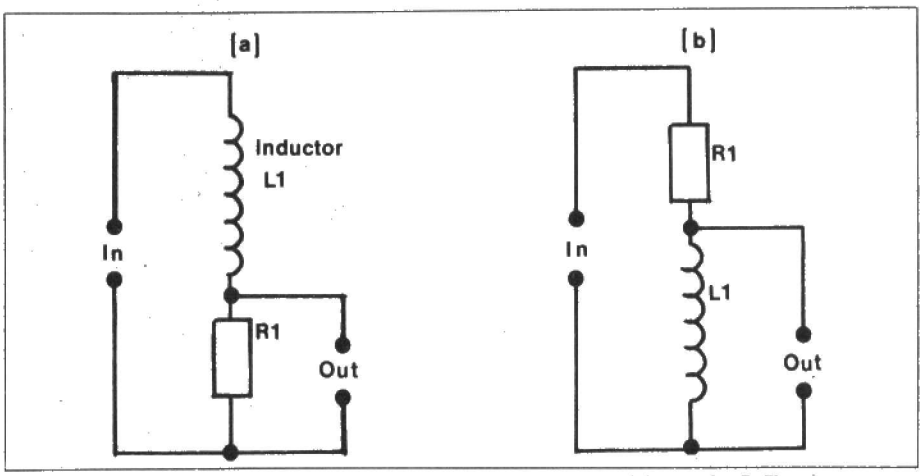



**Figure 1(a). A single section L - R low pass filter, (b) a single section high pass L - R filter.**

Reactance rising with increased frequency is caused by the limiting effect the inductance has on changes in current flow. With a very low input frequency the current flow would rise and fall very slowly anyway, but with a high input frequency even quite a modest inductance value will severely limit changes in current flow and provide a difficult path for the signal to negotiate. The greater the inductance of a component, the more it opposes changes in current flow, and the higher its reactance at any given frequency.

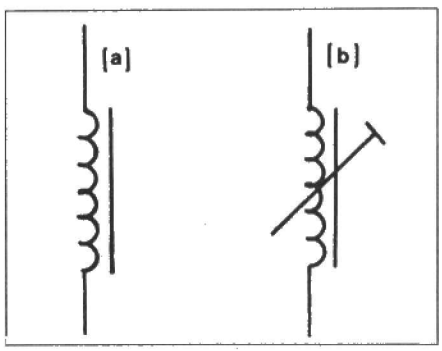



**Figure 2(a). The circuit symbol for an iron or ferrite cored inductor, (b) the circuit symbol for a variable inductance with an adjustable iron or ferrite core.**

### Filters

Simple filters using capacitors were discussed in an earlier "Starting Point" article, and inductors can be used in similar filters. Figure 1(a) shows the circuit of a simple L - R low pass filter, and Figure 1(b) gives the circuit of a simple high pass L - R filter. These diagrams also show the circuit symbol for an air cored inductor. Figure 2 shows the circuit symbols for iron cored and adjustable inductors.

Operation of these two filters is quite straight forward, and if we consider the low pass type first, at low frequencies L1 will have a reactance which is low in comparison to the resistance of R1. The losses through L1 due to a potential divider action are consequently very low. At higher frequencies the reactance of L1 is higher, and at some point losses through L1 start to rise to significant proportions. A doubling of frequency causes a doubling in the reactance of an inductor, and this gives a single stage L - R filter an ultimate attenuation rate of 6dB per octave (i.e. a doubling of input frequency causes the output signal to be reduced by 50%). This is the same roll-off rate as that obtained using a simple C - R filter.

The high pass filter operates in the same basic way, except that it is at high frequencies where the reactance of L1 is high that low losses are produced, and at low frequencies where L1 has a low reactance that large losses are produced through R1.

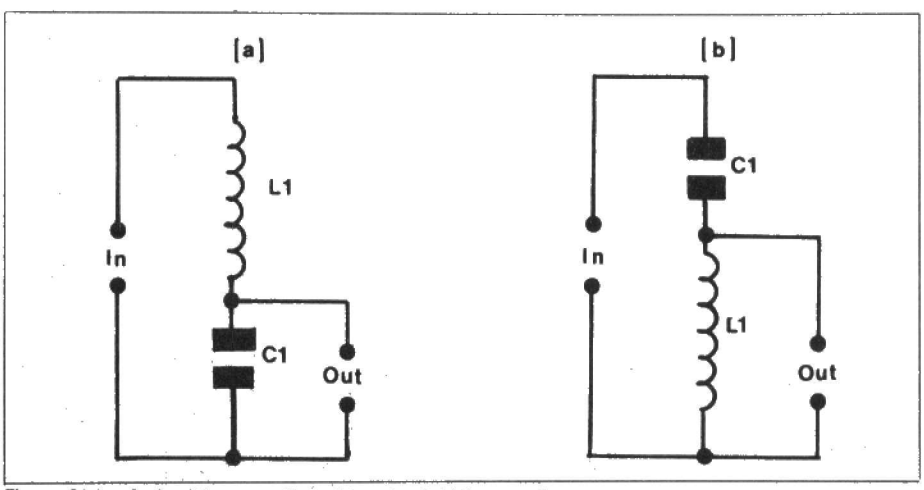



**Figure 3(a). An L - C low pass filter, (b) an L - C high pass filter.**

Like the low pass filter, the high pass one has a 6dB per octave attenuation rate.

It is possible to use both capacitors and inductors in filters to give an increased roll off rate, and Figure 3(a) shows the circuit of a simple L - C low pass filter which uses one capacitor and a single inductor. The equivalent high pass filter circuit is provided in Figure 3(b).

With these filters there is not just the attenuation provided by the doubling in the reactance of the inductor with a doubling of the input frequency, but also an attendant halving in the reactance of the capacitor. This gives a roll-off rate of 12dB per octave, with a doubling or halving of frequency (as appropriate for the type of filter) giving a 75% reduction in the amplitude of the output signal.

L - C filters are much used in cross-over networks in loudspeaker systems, and it is quite common for high pass and low pass filters to be connected in series to give a simple bandpass filter which directs middle audio frequencies to the appropriate drive unit. It is also quite common for L - C filters to be employed in transmitters and receivers to prevent R.F. signals breaking through to parts of the circuit where they could cause instability. Another application for L - C filters is at the output of transmitters where a low pass type can reduce harmonics which could otherwise cause radio and T.V. interference. However, in most other applications C - R filters are used.

The reactance of an inductor can be calculated using the following formula:-

$$XL = 2\pi FL$$

**Parallel Tuned Circuit**

A parallel tuned circuit simply consists of a capacitor and an inductor connected in parallel, as shown in Figure 4. At most frequencies this arrangement has a fairly low reactance with the capacitor providing

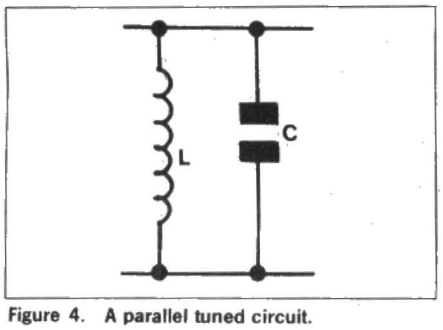



**Figure 4. A parallel tuned circuit.**

an easy signal path at high frequencies and the inductor providing a low reactance path at low frequencies. At a certain frequency though, the reactance of a parallel tuned circuits peaks at a very high level, and in theory there is actually infinite reactance at this "resonant frequency" as it is known. The resonant frequency is the one at which the inductor and capacitor have the same reactance value.

If we assume that the capacitor is given a charge, when the signal source is removed the capacitor will discharge into the inductor so that a new magnetic field builds up. When the capacitor has discharged, the magnetic field collapses and produces a voltage in the inductor. This voltage is of opposite polarity to the original input signal, and it charges up the capacitor. The capacitor then discharges into the inductor again, and this process continues indefinitely with an A.C. signal at the resonant frequency being produced across the tuned circuit.

In practice the oscillations do in fact rapidly die away due to losses caused by factors such as resistance in the wire used in the winding of the inductor, and leakage through the capacitor. In theory any signal fed into the tuned circuit remains in the tuned circuit so that no output is obtained if the circuit is inserted in a signal path, and the tuned circuit has infinite reactance. A practical tuned circuit will obviously not achieve this, but may still have a reactance of a few hundred kilohms or more.

Parallel tuned circuits are often used as bandpass filters, especially in radio equipment where only small and inexpensive inductors are required. The operating frequency of a filter of this type is easily varied by using a variable capacitor in the tuned circuit, or by adjusting the core of a variable inductance (the latter being known as permeability tuning). A filter of this type is thus ideal for use in the tuning circuits of radio receivers.

The basic method of using a parallel tuned circuit as a bandpass filter is shown in Figure 5. The input signal is provided by a

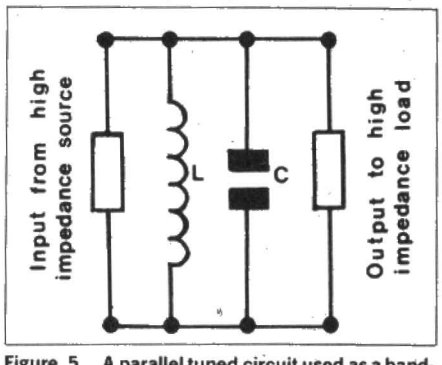



**Figure 5. A parallel tuned circuit used as a bandpass filter.**

fairly high impedance source, so that at most frequencies the low impedance of the filter seriously loads the source and gives little output. At and near the resonant frequency of the tuned circuit there is no significant loading of the signal source due to the very high reactance of the tuned circuit, and the signal can pass through to the output. A high impedance load must be present at the output since this is in parallel with the tuned circuit, and a low impedance here would effectively eliminate the high impedance of the tuned circuit at resonance and give very poor results. It is possible to use a filter of this type with a low impedance source and load if the tuned circuit is used as part of a transformer, and one method of doing this is illustrated in Figure 6. Another method is to

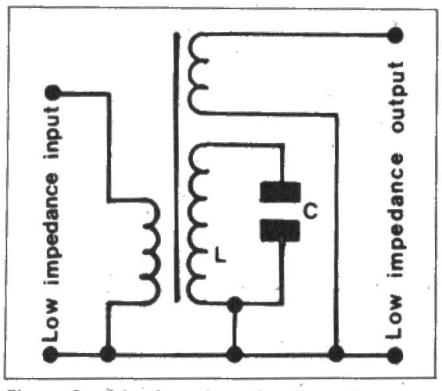



**Figure 6. A low impedance bandpass filter using a tuned circuit.**

use the tuned circuit as a single wound transformer with the input and output signals connected to tappings on the inductor.

**Series Tuned Circuit**

There is an alternative type of tuned circuit known as the "series tuned circuit", and as one might expect, this simply consists of an inductor and a capacitor wired in series instead of in parallel (see Figure 7). This provides a low impedance at most frequencies, like a parallel type, but at

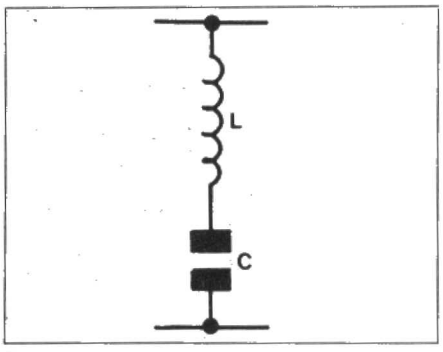



**Figure 7. A series tuned circuit.**

resonance it theoretically has zero impedance rather than an infinite impedance.

This type of tuned circuit is not as useful in practical applications as the parallel type, and it is not often encountered in electronic circuits.

The formula for calculating resonant frequency is the same for both the parallel and series types, and is as follows:-

$$f = \frac{1}{2\pi\sqrt{(LC)}}$$

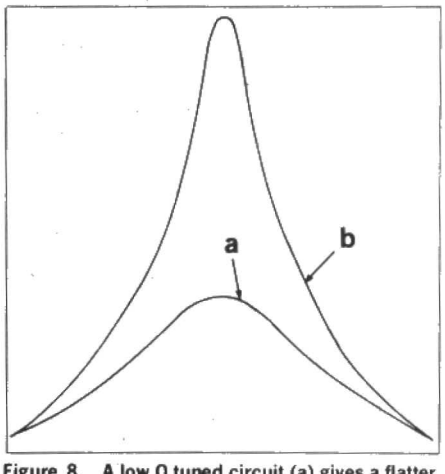



**Figure 8. A low Q tuned circuit (a) gives a flatter response than a high Q type (b).**

**Q Factor**

Although no practical tuned circuits quite achieve theoretical perfection, some are closer to this than others. The efficiency of a tuned circuit is known as its "Q", and the higher the Q value the more efficient the tuned circuit. The Q value is very important when a tuned circuit is used as a bandpass filter since it has a very large effect on the frequency response obtained.

A low Q tends to give a very "flat" response of the type shown in "a" of Figure 8. A high Q gives a very "sharp" response of the type shown in "b" of Figure 8. In order to obtain a reasonably high Q it is necessary for the inductor to be wound on a special core (usually made from a ferrite material) which gives a high inductance value for a winding of a given size, and sometimes special wire such as "Litz" wire is used in the winding. Litz wire is basically just a number of thin enamelled copper wires held together by a cotton covering. Radio frequency signals tend to flow down the outer part of wires and not along the centre of the wire, and this is known as the "skin effect". Litz wire gives a greater surface area and therefore a lower resistance than single strand wire of a comparable thickness, and thus gives higher Q in R.F. tuned circuits (but is of no benefit at low frequencies).

In some applications it is not possible to produce normal tuned circuits of sufficiently high Q, and it is then necessary to use alternatives such as crystal or mechanical filters which have similar electrical characteristics to ordinary L - C tuned filters, but are in other respects very different.

# THE ULTRASONIC INTRUDER DETECTOR

*by Dave Goodman*

- ★ **Range up to 20 feet (400 sq. ft. area)**
- ★ **Adjustable sensitivity**
- ★ **Direct connection to the Maplin Home Security System via our ultrasonic interface plug-in module**
- ★ **Single PCB construction with no setting up required**
- ★ **Up to three may be used on any Maplin Home Security System**

The new ultrasonic intruder detector is a worthwhile addition to your Maplin Home Security System. It will function over a much wider area than conventional switch contacts, it is highly portable, can be used almost anywhere, and can offer total security of a fairly large room.

The ultrasonic detector works on the Doppler Effect Principle (see issue 3, page 7), which in this case means transmission of a 40kHz carrier signal, and reception of the fundamental carrier along with additional frequency shifted signals. These extra signals can vary in frequency by up to 200Hz either side of the fundamental, and are quite small in amplitude. Several stages of

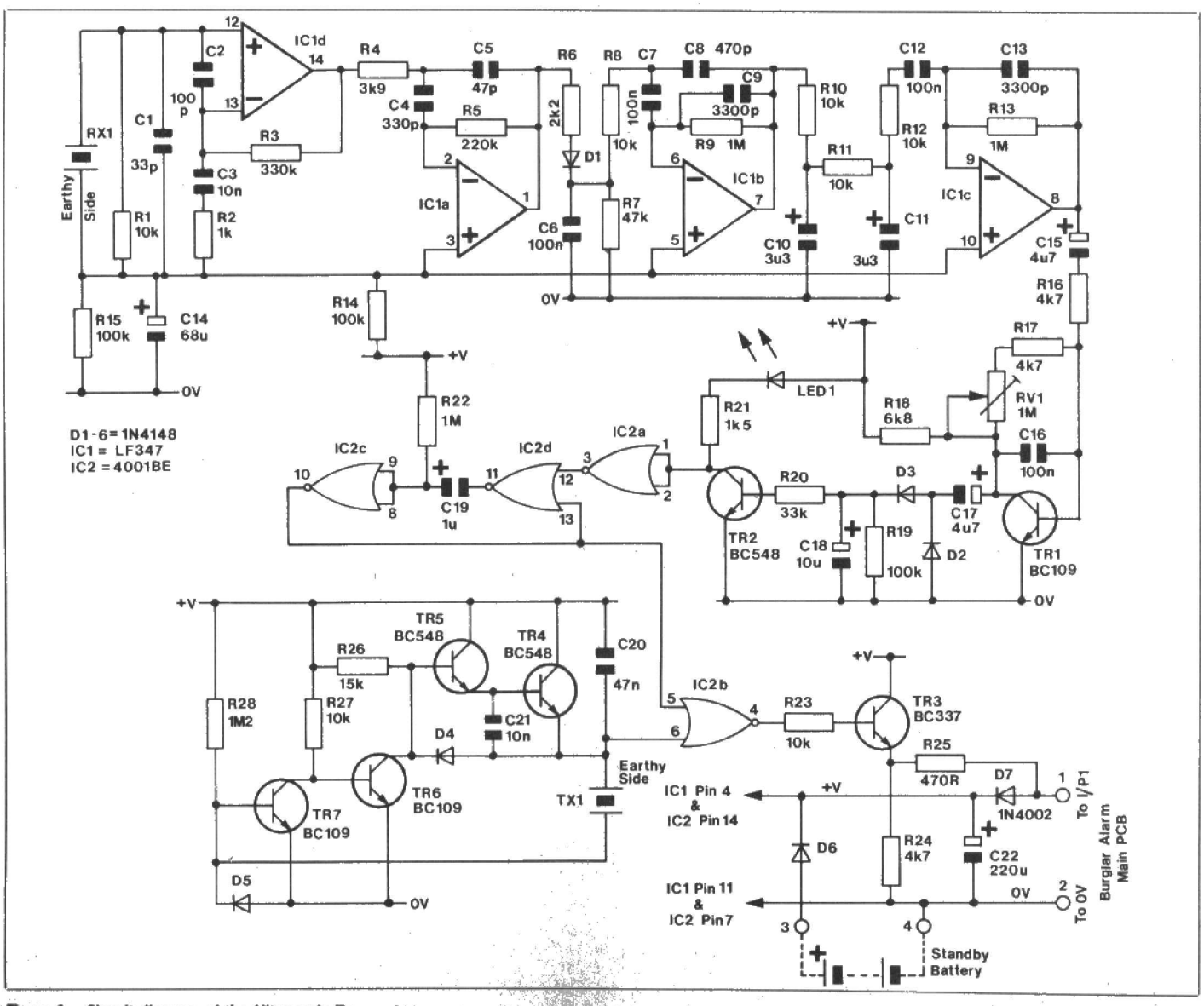



**Figure 1. Circuit diagram of the Ultrasonic Transceiver.**

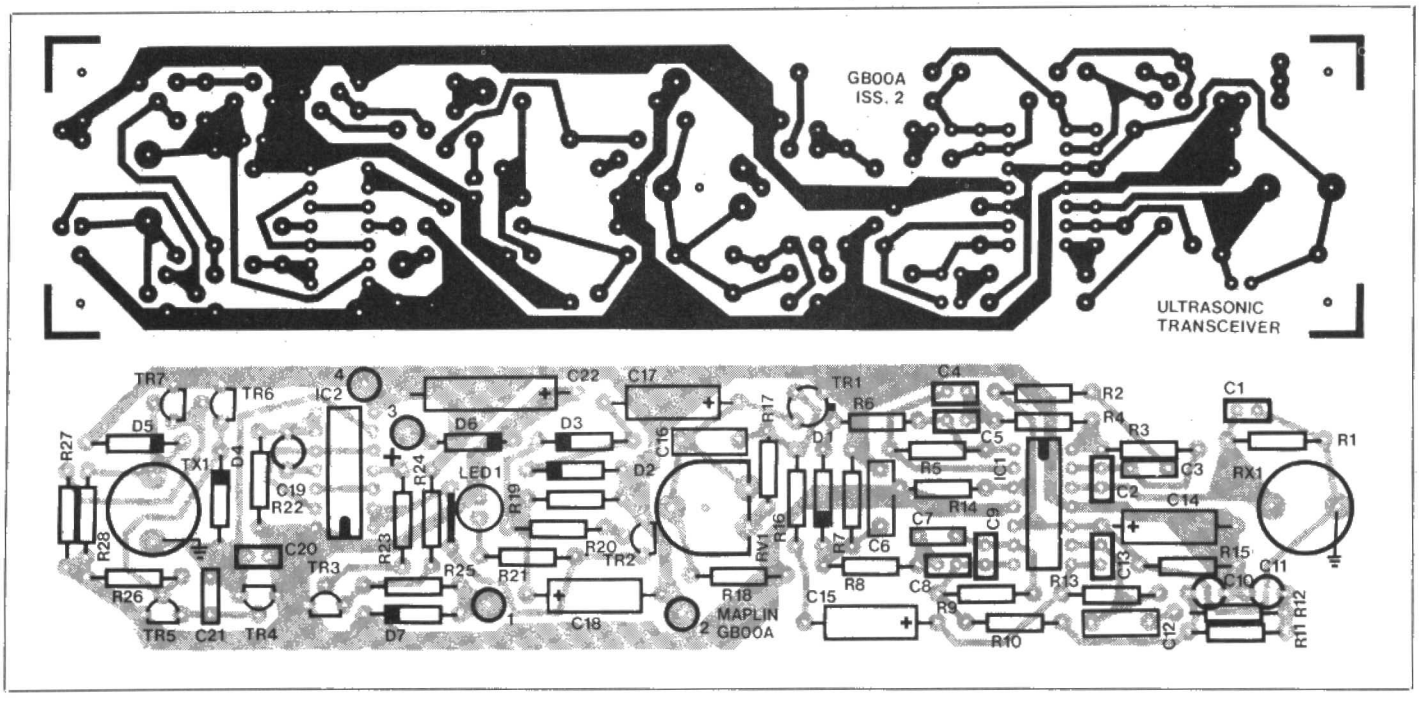
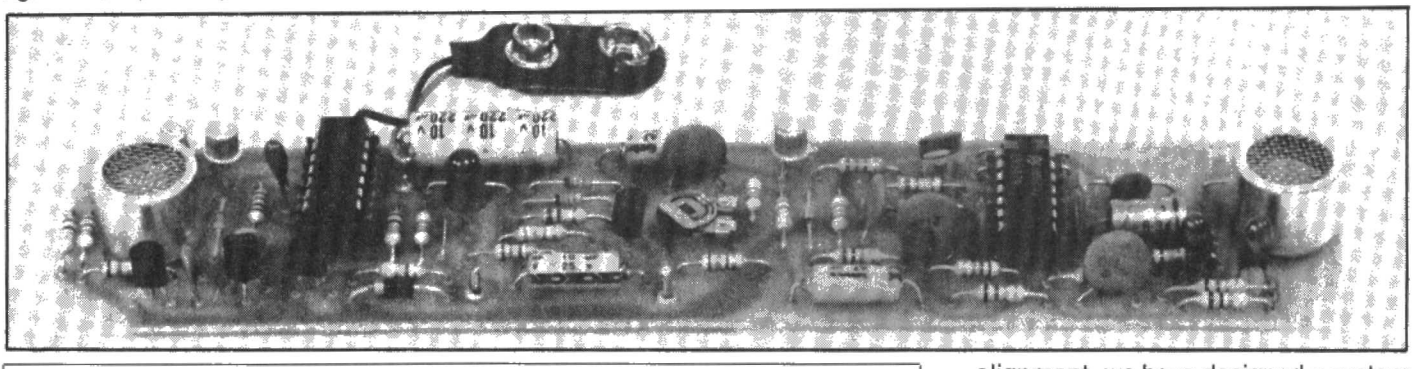



Figure 2. Component layout of the Ultrasonic Transceiver.



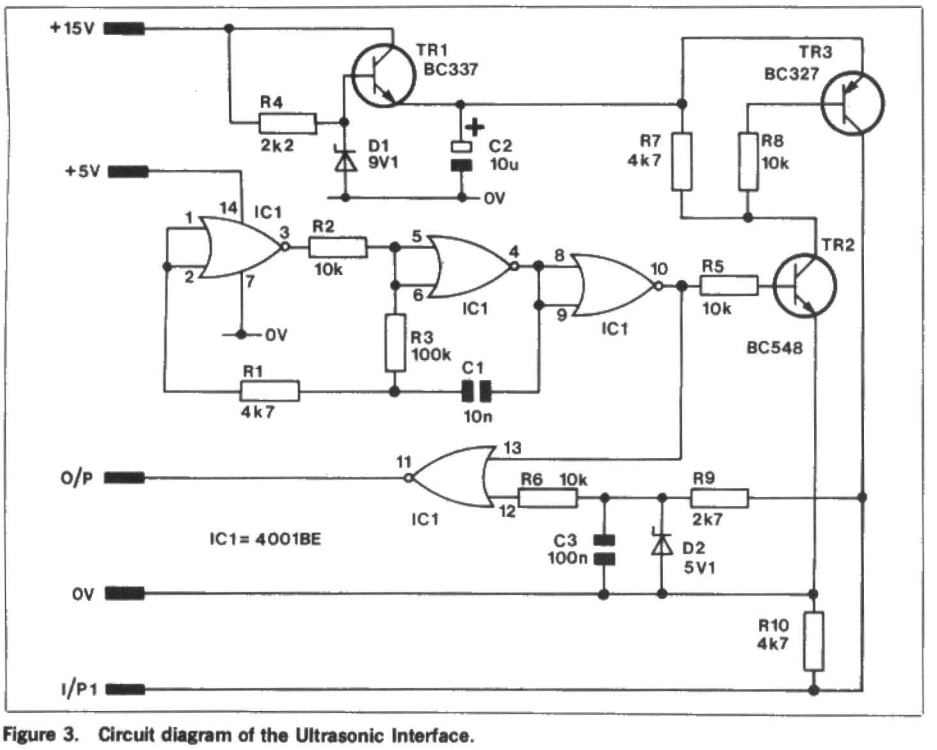



Figure 3. Circuit diagram of the Ultrasonic Interface.

filtering are required to remove the carrier, spurious r.f., and mains interference. The remaining signals are amplified, and, if they are sufficiently large, the alarm will be triggered. The level of triggering is dependent on the sensitivity setting. In this design the transmitter and receiver are both mounted on the same PCB, along with their associated circuitry, and signals are 'bounced' around the room.

### The Transmitter

As an improvement over conventional systems, in which the oscillator may require many tedious hours of alignment, we have designed a system in which the transducer determines the oscillator frequency, i.e. the circuit needs NO setting up at all.

The circuit TR4,5,6 and 7, allows the transducer to oscillate at its self-resonating point. C20 at switch-on discharges through the transducer, causing it to resonate. The produced signal is amplified by TR6 and 7, and a constant current circuit comprising TR4, 5 and D4, allows the necessary feedback for sustained oscillation. From this it can be seen that the normal operating frequency becomes dependent on the transducer.

### The Receiver

Ultrasonic signals transmitted in an enclosed area will reflect and bounce off hard surfaces, and be absorbed by soft surfaces. A percentage of these signals (called nodes and anti-nodes) are reflected back at the receiver transducer. The transmitter and receiver being matched pairs means that the receiver has a greater affinity for signals transmitted by its partner than for those produced by anything else. Because we are dealing with audio signals, it is possible for low frequency signals of sufficient amplitude (e.g. the rumble of a lorry going past) to trigger the intruder system, so filtering is required. Tests have shown that beat frequencies of between 5Hz and 100Hz can be produced by objects moving through

the ultrasonic field. C1 and C2 remove unwanted r.f. signals present at the input of ICId. This stage has a gain of 300, and high rejection of signals above the ultrasonic band. IC1a amplifies the received ultrasonic signals only, and has a first order response. D1 allows only the positive portion of the signal through, and the carrier part of the signal is removed by C6/R7, leaving only the lower frequency content of the signal. IC1b amplifies all low frequency (l.f.) signals, also filtering any possible remaining high frequency (h.f.) content. R10/11/12 and C10/11 form a low pass filter, which only allows signals below 50Hz to pass through to the final amplifying stage of IC1c. We should now be looking (on pin 8) at what is a stable threshold voltage of about +3v, modulated by l.f. signals of 5-50 Hz, and up to 5v in amplitude.

The stage comprising TR1, RV1, and R16/17 determines the overall sensitivity of the receiver, with a range from unity to x100. Amplified signal peaks are coupled to the diode pump D2/3, C18, R19, so that when the voltage across C18 develops more than 0.7v, sufficient current is produced to bias TR2 into conduction. LED1 illuminates. This has been included to give the user a means of visibly testing the circuit range and coverage (see setting-up procedure).

IC2a inverts and buffers the output from TR2. IC2c and IC2d form a monostable triggered by IC2a. IC2b is a control gate switching the 40kHz carrier from the transmitter oscillator to TR3.

With the working system in a stable condition the 40kHz carrier is coupled via R25 to the incoming supply rail. If the system is triggered the carrier is removed. Note that the supply rails connect to the burglar alarm via a plug-in module (the u/s interface PCB, GB01B).

A standby battery (PP3-9V) is shown connected, positive terminal to pin 3, and negative terminal to pin 4. Charging or 'topping up' facilities have not been added to this part of the circuit, so periodical checks on battery conditions are advisable. Note that the battery will not be required when using the transceiver in conjunction with a u/s interface PCB and our Home Security System, although it will be necessary to increase the NiCad battery pack from 7.8v to 9v. This can be accomplished with a total of eight NiCads (1.2v nominal) and two 6v battery holders (HF29G).

### Ultrasonic Interface PCB

This simple circuit identifies the carrier signals transmitted by the ultrasonics module. These signals appear between each 2ms current pulse (used for powering the transceiver), and allows monitoring of the two wire supply connection.

IC1a and b form a 500Hz CMOS oscillator, and switch the buffer transistor TR2 at this rate. The regulator D1, TR1, applies 8.6V d.c. to TR3, which is pulsed on and off by TR2, producing an 8.6V, 500Hz signal across R10. This signal is rectified by D7 and C22 (figure 1) in the transceiver, producing 8.2V on the positive rail.

IC1d has a 500Hz clock pulse on pin 13, and an in-phase signal of 500Hz on pin 12. The two signals cancel at the output, pin 11, producing an inverted trigger signal, which fires the burglar alarm. However, under normal conditions a carrier signal will be present across R10, appearing between each 2ms pulse. R6, R9, D2, and C3 filter and limit this composite signal, and ICId output remains low. Either disconnection of the supply, or triggering the transceiver will remove the 2ms 'carrier' from across R10, sending ICId output high (+5V), and setting off the alarm.

### Constructional Details for Ultrasonic Intruder Detector

Refer to the parts list and figure (2). Mount D1 to D7 ensuring correct orientation. Mount resistors R1 to R28, and capacitors C1 to C22. Check that the electrolytics C14, C15, C17, C18 and C22, also tantalums C10, C11 and C19 are mounted with correct polarisation. Electrolytics are marked at the negative end but tantalums at the positive. Fit the I.C. sockets, and all transistors. TR1, TR6, and TR7 have their emitters marked with a pip on the case, and should line up with the legend marked on the PCB. If a metal case is used, it is important that the transducers do not touch the chassis. The transducers each have one pin connected directly to their case, and this pin should be connected to the hole marked ⏚ (figure 2).

### Assembly of Ultrasonic Trigger

Observe the usual precautions when mounting components. Use an I.C. holder, for IC1, and double-check all solder joints. Plug the module into any channel on the main PCB of the Home Security System (issue 2, figure 5), and apply power. If you have a voltmeter, check across pins OV and I/P 1 on the main PCB. This should read approx. 5.0V dc. Also the selected channel should trigger, and the monitoring LED will light.

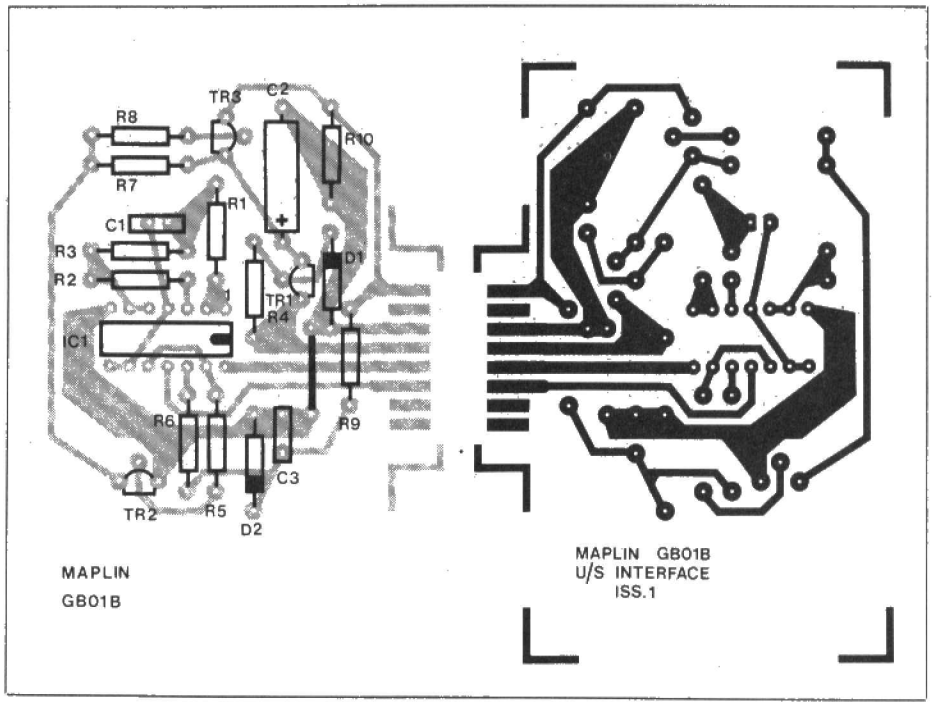
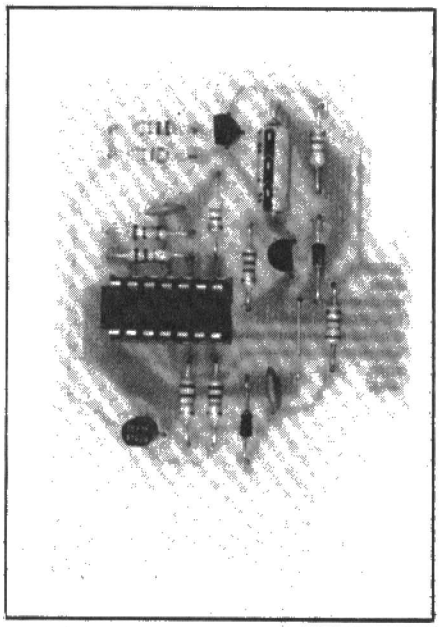



**Figure 4. Component layout of the Ultrasonic Interface.**



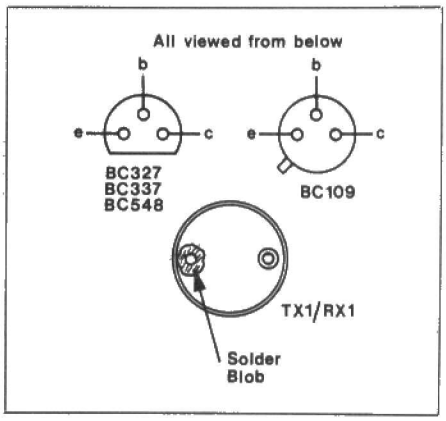



**Figure 5. Pin Designations.**

### Setting Up

Set RV1 anti-clockwise. Connect a 9V battery across pin 3 (positive) and pin 4 (negative). LED 1 should come on for a few seconds and then extinguish. Allow 30 seconds settling time, and then wave your hand about six inches away from the transducers. Response to movement should be indicated by LED 1 illuminating, and it should remain so for a few seconds. If there is no response, turn RV1 to approximately ¼ travel to increase sensitivity, and repeat check. If the LED now stays on, move away to a point where the LED is still visible, and keep completely still. After a few seconds the LED should go out. If the circuit still does not work, try disconnecting the battery, and repeating the above checks. If all is satisfactory remove the battery and connect the transceiver to the Maplin Home Security System main PCB.

Use either bell wire, or our 4-wire phone cable (XR66W) to connect the transceiver to the main PCB (burglar alarm). Pin 2 will connect to OV and Pin 1 will connect to I/P 1.

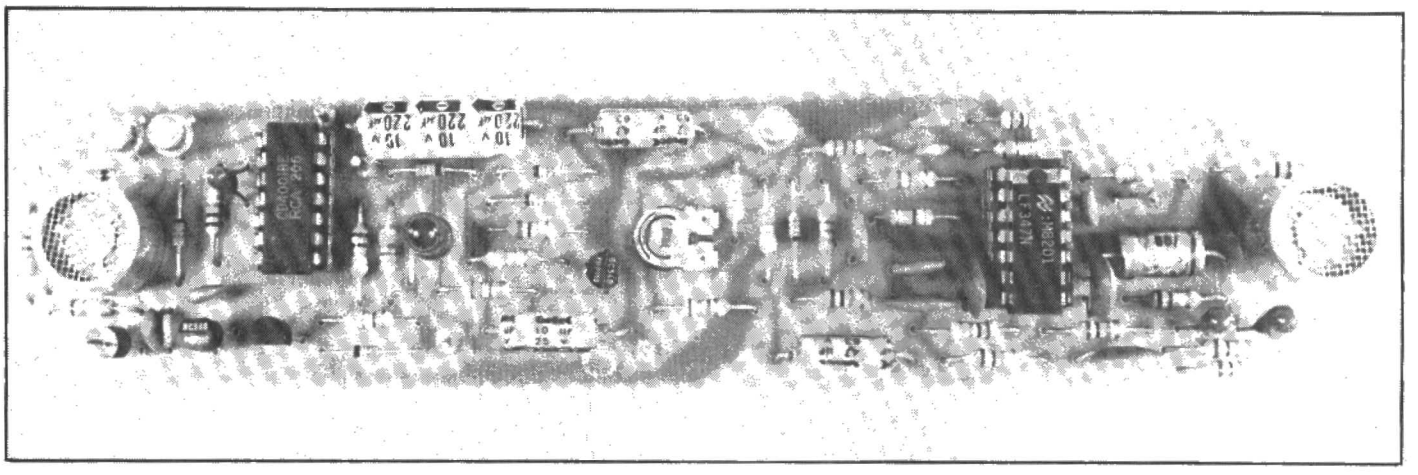
Whatever channel is used for this project, ensure that a u/s interface module is plugged in to this position only.

At switch-on the burglar alarm channel LED will flash. Allow about a minute for the transceiver to stabilise. Turn the sensitivity control RV1 clockwise, to suit conditions, and set the key switch for 'ARM'. Don't forget to switch in the selected channel (switches 3 to 8).

If stand-by batteries are to be used, remove the mains supply, then reconnect. Check that the system does not trigger. If all is well, experiment with RV1 settings for optimum results before putting into service.

### Using Ultrasonics

The module is best placed in a corner of the room to be protected, preferably just below ceiling level, and inclined at an angle of 30 to 45 degrees downwards. Keep as far away as possible from windows, radiators, central heating thermostats, and telephones and bells. Remember that anything that moves (e.g. curtains, telephone bells) can set off the alarm, dependent on sensitivity. RV1 must now be adjusted for required sensitivity. Obviously, the more sensitive the system, the greater the possibility of false triggerings occurring. If areas greater than 400 square feet need covering, then two or more devices may be used. Note that each transceiver will draw 24mA, and up to three may be used on one system, dependent on what else is connected to the system.



## ULTRASONIC TRANSCEIVER PARTS LIST

Resistors: All ½W 5% carbon

| | | | |
|---|---|---|---|
| R1,8,10-12 inc,23,27 | 10k | (7 off) | (M10K) |
| R2 | 1k | | (M1K) |
| R3 | 330K | | (M330K) |
| R4 | 3k9 | | (M3K9) |
| R5 | 220k | | (M220K) |
| R6 | 2k2 | | (M2K2) |
| R7 | 47k | | (M47K) |
| R9,13,22 | 1M | (3 off) | (M1M) |
| R14,15,19 | 100k | (3 off) | (M100K) |
| R16,17,24 | 4k7 | (3 off) | (M4K7) |
| R18 | 6k8 | | (M6K8) |
| R20 | 33k | | (M33K) |
| R21 | 1k5 | | (M1K5) |
| R25 | 470R | | (M470R) |
| R26 | 15k | | (M15K) |
| R28 | 1M2 | | (M1M2) |
| RV1 | 1M hor sub-min preset | | (WR64U) |

Capacitors

| | | | |
|---|---|---|---|
| C1 | 33pF ceramic | | (WX50E) |
| C2 | 100pF ceramic | | (WX56L) |
| C3,21 | 10nF disc ceramic | (2 off) | (BX00A) |
| C4 | 330pF ceramic | | (WX62S) |
| C5 | 47pF ceramic | | (WX52G) |
| C6,7,12,16 | 100nf disc ceramic | (4 off) | (BX03D) |
| C8 | 470pF ceramic | | (WX64U) |
| C9,13 | 3300pF ceramic | (2 off) | (WX74R) |
| C10,11 | 3u3F 35V tantalum | (2 off) | (WW63T) |
| C14 | 68uF 6V3 axial electrolytic | | (FB44X) |
| C15,17 | 4u7F 63V axial electrolytic | (2 off) | (FB18U) |
| C18 | 10uF 25V axial electrolytic | | (FB22Y) |
| C19 | 1uF 35V tantalum | | (WW60Q) |
| C20 | 47nf minidisc | | (YR74R) |
| C22 | 220uF 10V axial electrolytic | | (FB60Q) |

Semiconductors

| | | | |
|---|---|---|---|
| D1-6 inc. | 1N4148 | (6 off) | (QL80B) |
| D7 | 1N4002 | | (QL74R) |
| LED 1 | LED RED | | (WL27E) |
| TR1,6,7 | BC109c | (3 off) | (QB33L) |
| TR2,4,5 | BC548 | (3 off) | (QB73Q) |
| TR3 | BC337 | | (QB68Y) |
| IC1 | LF347 | | (WQ29G) |
| IC2 | 4001BE | | (QX01B) |

Miscellaneous

| | | | |
|---|---|---|---|
| TX1/RX1 | Ultrasonic transducers (pair) | | (HY12N) |
| | Veropin 2141 | | (FL21X) |
| | 14 pin DIL Skt | (2 off) | (BL18U) |
| | Ultrasonic Transceiver PCB | | (GB00A) |

A complete kit of all the above parts is available.
Order As LW83E (Ultrasonic Xceiver Kit) Price £12.25

## U/SONIC INTERFACE PARTS LIST

Resistors: All ½W 5% carbon

| | | | |
|---|---|---|---|
| R1,7,10 | 4k7 | (3 off) | (M4K7) |
| R2,5,6,8 | 10k | (4 off) | (M10K) |
| R3 | 100k | | (M100K) |
| R4 | 2k2 | | (M2K2) |
| R9 | 2k7 | | (M2K7) |

Capacitors

| | | | |
|---|---|---|---|
| C1 | 10nF mini disc | | (YR73Q) |
| C2 | 10uF 25V axial electrolytic | | (FB22Y) |
| C3 | 100nF mini disc | | (YR75S) |

Semiconductors

| | | | |
|---|---|---|---|
| D1 | BZY88 C9V1 | | (QH13P) |
| D2 | BZY88 C5V1 | | (QH07H) |
| TR1 | BC337 | | (QB68Y) |
| TR2 | BC548 | | (QB73Q) |
| TR3 | BC327 | | (QB66W) |
| IC1 | 4001BE | | (QX01B) |

Miscellaneous

| | | | |
|---|---|---|---|
| | 14 pin DIL Skt | | (BL18U) |
| | U/S Interface PCB | | (GB01B) |

A complete kit of all the above parts is available.
Order As LW84F (Ultrasonic Interface Kit) Price £2.50

# BASICALLY BASIC

*Graham Hall, B.Sc.* Part 13

This month we continue to describe the string functions available in BASIC. Table 1 provides a summary of the common string functions and explains their use.

## LEFT$ Function

The LEFT$ function creates a substring from a main string specified as an argument to the function. The general format of the LEFT$ function is:
LEFT$ (X$, n)
where X$ is the main string and n specifies the length of the substring. The argument n can be an integer or an expression. If the expression evaluates to a non-integer value BASIC truncates the result to an integer. The substring is formed from the first character (left-most character) of the main string to the boundary specified by n. If n is greater than the number of characters in the main string the entire string is returned. If n is zero or less than zero, a blank (null or empty) string is returned.

The following program demonstrates the use of the LEFT$ function:

```
10 LET X$ = "MAPLIN ELECTRONIC SUPPLIES LTD"
20 LET A$ = LEFT$ (X$,6)
30 PRINT A$
40 LET B$ = LEFT$ (X$,0)
50 PRINT B$
60 PRINT LEFT$ (X$,33)
70 END
RUN

MAPLIN

MAPLIN ELECTRONIC SUPPLIES LTD
```

## RIGHT$ Function

The RIGHT$ function is similar to LEFT$ function in that it creates a substring from a main string. The substring is formed from a boundary specified as an argument to the function, to the last (right-most) character in the main string. The general format of the RIGHT$ function is:
RIGHT$ (X$,n)
where X$ is the main string and n is the position of the first character in the substring. The argument n can be an integer or an expression. If the expression evaluates to a non-integer value BASIC truncates the result to an integer. If n is greater than the number of characters in the main string a null string is returned.

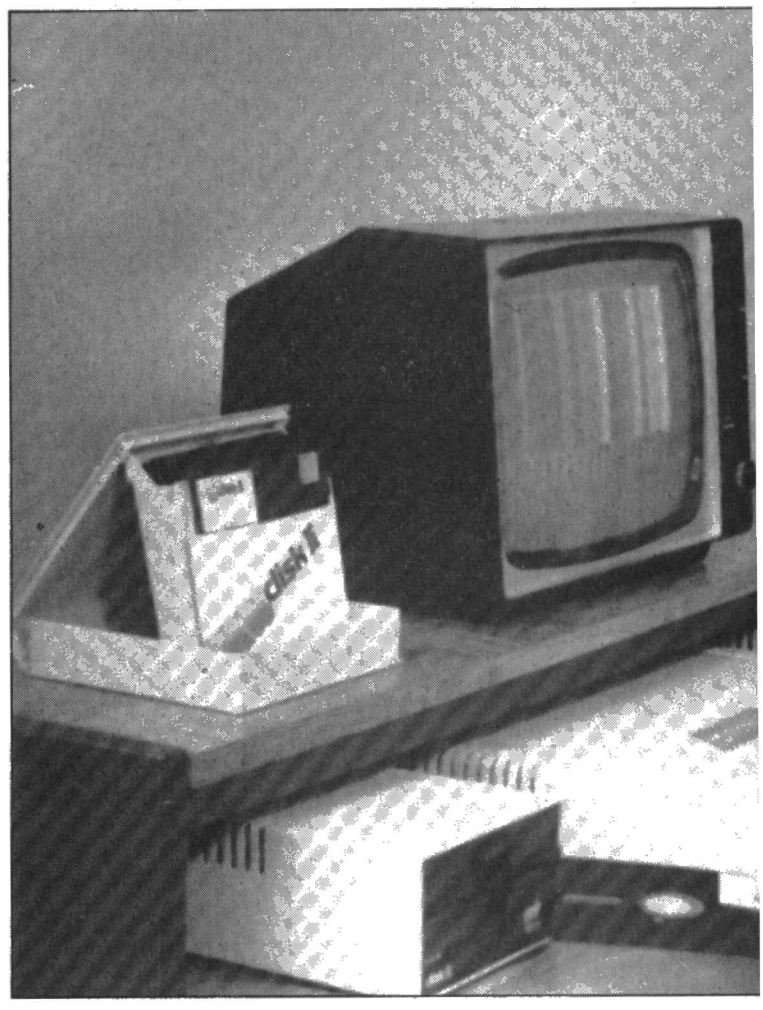
The following program demonstrates the use of the RIGHT$ function:

```
10 LET X$ = "MAPLIN ELECTRONIC SUPPLIES LTD"
20 LET A$ = RIGHT$ (X$,8)
30 PRINT A$
40 PRINT RIGHT$ (X$,31)
50 PRINT RIGHT$ (X$,1)
60 END
RUN

ELECTRONIC SUPPLIES LTD

MAPLIN ELECTRONIC SUPPLIES LTD
```

The substring returned by the RIGHT$ function on line 40 is a null string because the position of the first character in the substring (specified as an argument to the function) is greater than the number of characters in the main string.

## MID$ Function

The MID$ (middle) function creates a substring from a specified main string within boundaries specified to the function as arguments. The general format of the MID$ function is:
MID$ (X$,n1,n2)
where X$ is the main string, n1 is the starting position of the substring and n2 is the number of characters in the substring. The arguments n1 and n2 can be integers or expressions the results of which are truncated to an integer value if necessary. If n2 is zero a null string is returned. If n1 or n2 is less than zero, an error message is given.



The following program demonstrates the use of the MID$ function:

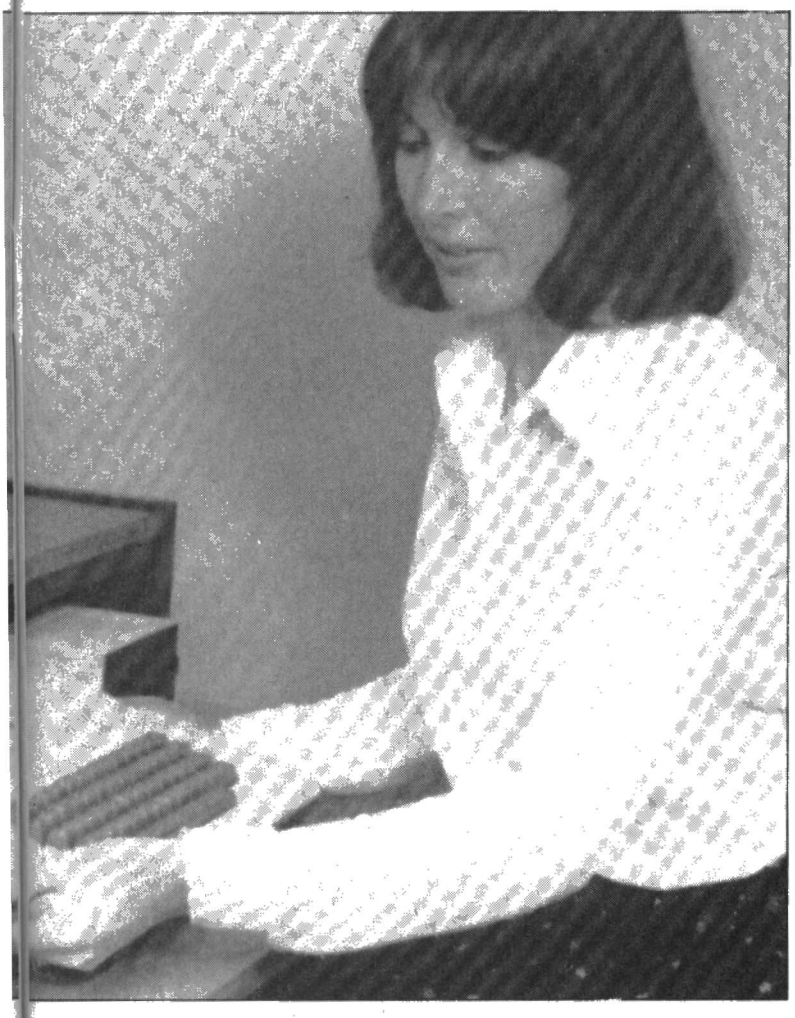
```
10 LET X$ = "MAPLIN ELECTRONIC SUPPLIES LTD"
20 LET A$ = MID$ (X$,8,10)
30 PRINT A$
40 PRINT MID$ (X$,19,20)
50 END
RUN

ELECTRONIC
SUPPLIES LTD
```

In line 40 of the program the argument to the MID$ function specifies a substring beginning at the nineteenth character of the main string. The number specified for the length of the substring exceeds the number of remaining characters in the main string, hence the entire string from the nineteenth character is printed.

## LEN Function

The LEN (length) function returns the character count of a string given as an argument. The general format of the LEN function is:
LEN (string)
where string can be a string constant or a string variable. Tabs and spaces within a string are counted as significant characters. The following program demonstrates the use of the LEN function:

```
10 LET X$="MAPLIN SUPPLIES"
20 PRINT "LENGTH OF STRING=":LEN(X$)
30 FOR I=1 TO LEN(X$)
40 PRINT LEFT$(X$,I)
50 NEXT I
60 END
RUN
```



```
LENGTH OF STRING=15
M
MA
MAP
MAPL
MAPLI
MAPLIN
MAPLIN
MAPLIN S
MAPLIN SU
MAPLIN SUP
MAPLIN SUPP
MAPLIN SUPPL
MAPLIN SUPPLI
MAPLIN SUPPLIE
MAPLIN SUPPLIES
```

Line 1Ø assigns the string 'MAPLIN SUPPLIES' to the string variable X$. Line 2Ø prints the message within double quotes followed by the length of the string assigned to X$, returned by the LEN function. The space between the word 'MAPLIN' and the word 'SUPPLIES' is counted as a significant character so the length of the string is fifteen. The FOR statement, lines 3Ø, 4Ø and 5Ø, initialises the variable 'I' to one and sets the limit of the loop to the value returned by the LEN function. Its corresponding NEXT statement is on line 5Ø. Each time the loop is executed a substring is created and printed. The LEFT$ function on line 4Ø is given the loop variable 'I' as the argument which determines the length of the substring.

Each time the loop is executed 'I' is incremented by one, subsequently the substring printed is increased by one character. The output from the program is shown following the RUN command. Line 6Ø — the END statement signifies the finish of the program.

| Function | Application |
|---|---|
| ASC(X$) | Converts the first character in the string, X$, to its equivalent ASCII value. |
| CHR$(X) | Converts the ASCII code number, X, to its equivalent character. |
| LEFT$(X$,n) | Creates a substring from the string X$ in a range from the left-most character to the nth character. |
| LEN(X$) | Returns the number of characters in the string X$. |
| MID(X$,n1,n2) | Creates a substring from the string X$, that begins at position n1 and is n2 characters long. |
| RIGHT(X$,n) | Creates a substring from the string X$ in a range from n to the right-most character. |
| STR$(X) | Converts the contents of numeric variable X to the ASCII character string equivalent. |
| VAL(X$) | Converts a specified string of numeric characters to a numeric value. |

**Table 1. BASIC string functions.**

## STR$ Function

The STR$ function is used to convert a numeric variable to a string of ASCII characters. The string is the character equivalent of the numeric content of the variable. The general format of the STR$ function is:

STR$ (variable).

The following program demonstrates the use of the STR$ function:

```
1Ø LET A=365
2Ø LET X$=STR$(A)
3Ø PRINT X$
4Ø PRINT MID$(X$,2,1)
5Ø END
RUN

365
6
```

The integer 365 is assigned to the numeric variable 'A'. Line 2Ø uses the STR$ function to convert the contents of 'A' to its equivalent ASCII string, which is then assigned to the string variable X$. Line 3Ø prints X$. To demonstrate that an ASCII string has been created, line 4Ø uses the MID$ function to extract the middle character from the string X$. This is printed on the terminal.

## VAL Function

The VAL (value) function converts a string of numeric characters to a numeric value. This is the opposite of the STR$ function. The general format of the VAL function is:

VAL (string)

where the argument is a character string or string variable. If the argument string contains a non-numeric character an error message will be output.

The following program demonstrates the use of the VAL function:

```
1Ø LET X$="1234"
2Ø LET A=VAL(X$)
3Ø PRINT A
4Ø END
RUN

1234
```

## String Concatenation

Some versions of BASIC include a concatenation symbol (+) which can be used to combine string variables or string constants to generate a new string. For example the command PRINT "HEL" + "LO" will output the string HELLO on the terminal. Consider the following program:

```
1Ø LET A$="MAPLIN "
2Ø LET B$="ELECTRONIC "
3Ø LET C$="SUPPLIES"
4Ø LET D$=A$+B$+C$
5Ø PRINT D$
6Ø END
RUN

MAPLIN ELECTRONIC SUPPLIES
```

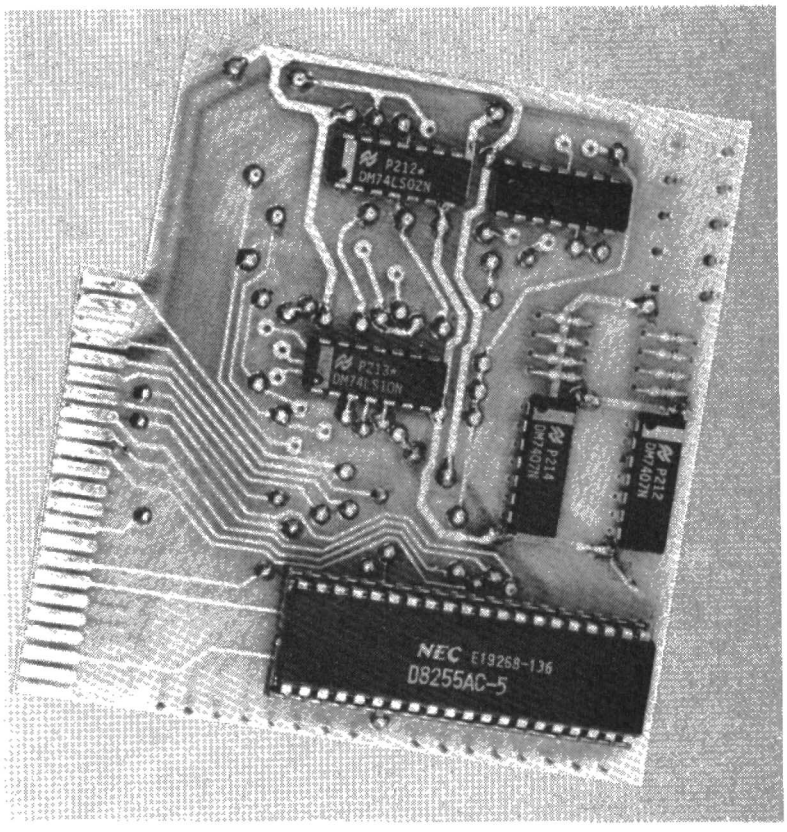
The concatenation symbol is used on line 4Ø to concatenate the strings assigned to the string variables A$, B$ and C$. The new string is assigned to the string variable D$ and printed by the statement on line 5Ø. If the concatenation symbol is used illegally, such as on the left side of an assignment statement, an error message will be output to the terminal. For example, 1Ø LET W$ + 2$ = Y$ is illegal and returns an error message. ■

In response to the many enquiries we have received about this extremely popular article, we will shortly be making the complete series available in book form at low cost. Watch this space for further details!

# ZX81 INPUT~OUTPUT PORT

*by A. Daykin*

- ★ **Two 'bi-directional' ports for a total of 16 input or 16 output lines**
- ★ **One buffered output port which can interface directly to CMOS**
- ★ **Able to be used with the MAPLIN digital train controller**
- ★ **On board address selection allows for expansion to 6 ports with two PCBs**




This project for the Sinclair ZX81 will give you access to the outside world with your '81'.

The I/O port, shown in figure 1, gives many possible modes of operation. For the purposes of this article examples are given for only the simplest, although the 8255 used here has a total of three programmable operations.

MODE '0' provides 3x8bit ports, two of which can be programmed to function either as inputs or outputs, and one (port B), as a buffered output only, which can directly drive the MAPLIN DIGITAL TRAIN CONTROLLER (issue three) or, indeed, many other forms of hardware with a minimum of interfacing.

## Circuit Description

Figure 1 shows a complete circuit diagram of the board, and Figure 5 shows the alternative address decoder circuitry. The MP8255 (IC4) has two address lines, pins 8 and 9, which are connected directly to the ZX81 address lines A1 and AØ. The remainder of the address decoding is performed by ICs 1,2, and 3, which enables the MP8255 with a logic Ø at pin 6 ($\overline{CS}$).

Data lines DØ to D7 are connected directly to IC4, along with write and read lines $\overline{WR}$ and $\overline{RD}$. The RESET line, P35, has been tied directly to 0v. Should an external reset be required, the track will have to be broken here, and an external reset pin fitted to P35. Two possible address groups are provided on the PCB, which can be selected at the construction stage, by inserting appropriate pins through the PCB. Addresses used are 16360 to 16363, which are designated by a square symbol on the legend, and 16380 to 16383, which are designated by a circle on the legend. All other track pins have a broken circle for designation. If two PCBs are used, they should be constructed for two different address groups.

IC5 and 6 are 7407 buffers, with open collector outputs capable of sinking up to 40mA at a maximum of 30v.

## Construction

Commence by inserting all track pins into the holes marked with a broken circle. Decide which address group you require, and insert all track pins into their appropriate holes (see circuit description). Fit R1 to R8, and D1 (note polarity). Insert all 26 Vero pins and push home. Solder all pins and components, remembering that the track pins will need soldering to both sides of the PCB. Fit the 40 pin IC socket and ICs 1, 2, 3, 5, and 6. Solder these components in place and, finally, insert IC4 in the socket. Cut off any protruding leads and clean flux off the PCB with a stiff brush and thinners. Check all components and joints before connecting to your computer. If you are using a mother board the PCB will plug straight in, but if you are using the port direct into the ZX81 a 23-way socket (RK35Q) will be required. Place this socket over the edge connector, aligning pin 3 with the slot cut in the PCB, and solder all 44 pins to both sides of the board.

## Testing And Using The Ports

With the power off, plug the port PCB into your ZX81. Switch on and ensure that the command cursor appears. If not, or if the screen fills with lines, switch off and re-check your assembly.

A few lines of BASIC program are now required for use. The highest address (16363 or 16383), used for the

| Control Word | D7 | D6 | D5 | D4 | D3 | D2 | D1 | DØ | Port A | Port C Upper | Port C Lower | Port B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 128 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Output | Output | Output | Output |
| 129 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Output | Output | Input | Output |
| 136 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | Output | Input | Output | Output |
| 137 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | Output | Input | Input | Output |
| 144 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | Input | Output | Output | Output |
| 145 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Input | Output | Input | Output |
| 152 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | Input | Input | Output | Output |
| 153 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | Input | Input | Input | Output |

**Table 1. List of Control Words.**

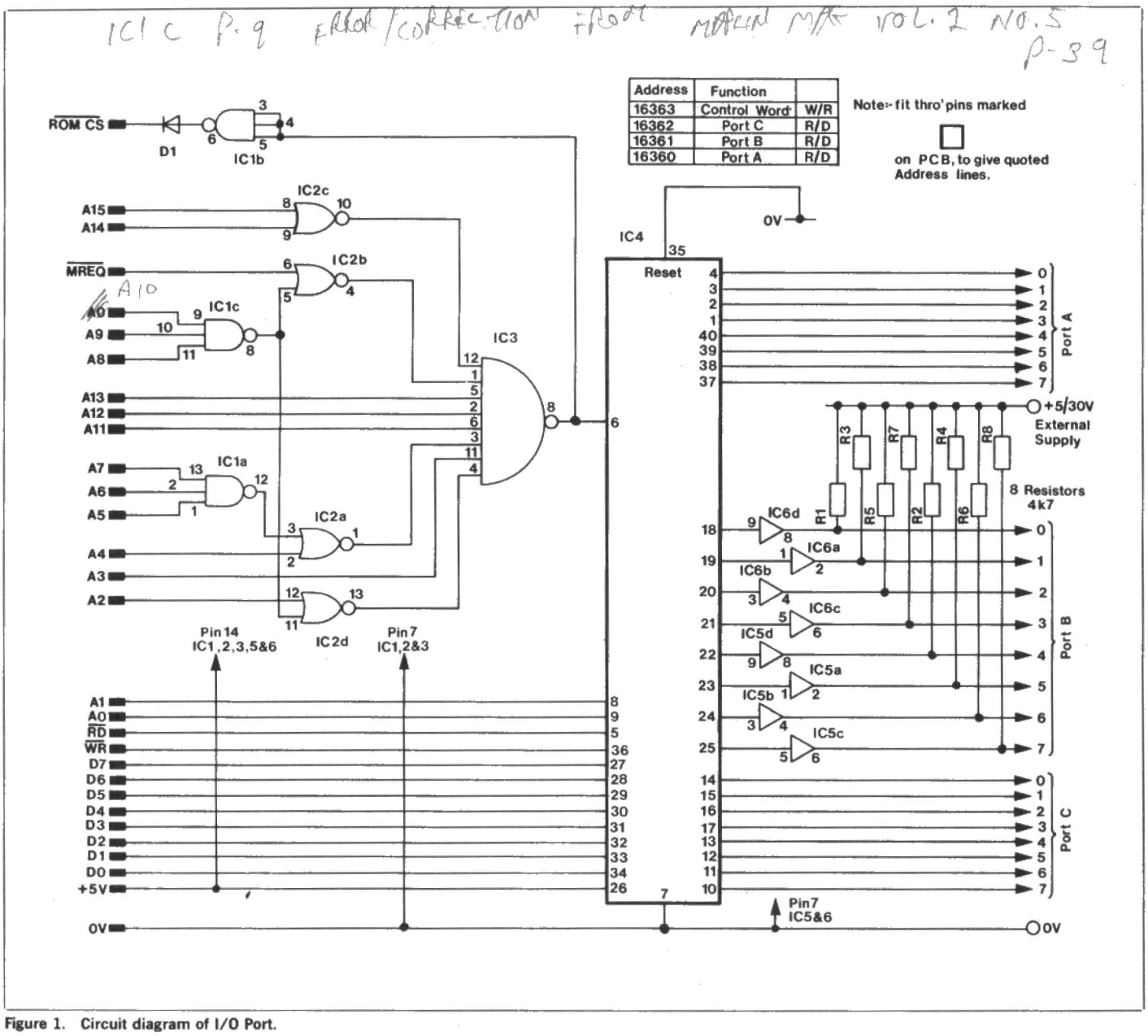



**Figure 1. Circuit diagram of I/O Port.**

CONTROL WORD, will set MODE and program which ports are to be input and output (see table 1).

PORT A can be used as either input or output, but all the DATA lines will be in the same mode.

PORT B on our PCB can only be used as an output, because of the buffers.

PORT C can be either input or output, and may also be split into two parts, upper and lower halves, which can be changed independently.

Table 1 gives a complete list of the CONTROL WORDS available, along with DATA BUS state and a definition of PORT USE.

Reliable operation with PORT C in split mode can be difficult when using BASIC, and it is advisable to use only the control words 128, 137, 144, and 153. Port A is located at address 16360 or 16380, and if used as an output POKEing to this address will output data on the port pins. PEEKing at the same address will read data in from the same pins. Port B is located at address 16361 or 16381, and can only be POKEd here.

## I/O PORT PARTS LIST

| | | | |
|---|---|---|---|
| Resistors — all ¼W 5% carbon unless specified | | | |
| R1-8 | 4k7 | 8 off | (U4K7) |
| **Semiconductors** | | | |
| D1 | 1N4148 | | (QL80B) |
| IC1 | 74LS10 | | (YF08J) |
| IC2 | 74LS02 | | (YF02C) |
| IC3 | 74LS30 | | (YF20W) |
| IC4 | 8255A PIA | | (YH50E) |
| IC5,6 | 7407 | 2 off | (QX76H) |
| **Miscellaneous** | | | |
| | 40-pin DIL socket | | (HQ38R) |
| | Veropin 2145 | 1 pkt | (FL24B) |
| | Track pin | 2 pkt | (FL82D) |
| | PCB | | (GA90X) |
| **Test Components** | | | |
| | 2k2 resistors | 4 off | (M2K2) |
| | 220R resistor | | (M220R) |
| | LED red | 8 off | (WL27E) |
| or | Red bargraph display | | (BY65V) |

A complete kit is available for this project. It does NOT include the Test Components.

**Order As LW76H (I/O Port Kit) Price £9.25**

Port C is located at address 16362 or 16382, and can be POKEd or PEEKed as for port A. Printed here are two demo programs which will quickly check out your board. For demo 1 a number of discrete LEDs or a bar-graph display can be connected to 0v via a 220 ohm resistor, and then to the outputs of port B (see figure 4). Remember to connect the positive supply pin (next to port B pin 0) to a +5v/30v supply.

For the demo 2 program the LEDs can be left connected, and will give a display similar to that of the previous program. Input coding can be set up by wiring port A and C pins to either 0v or +5v, as required, but for test purposes connect the 0v and +5v via 2k2 resistors (figure 5) in case the MP8255 is set in the output mode. This should be done before running the program.

For constructors who may wish to use the I/O port with external hardware, a mother board is available for the ZX81 (GB08J) and will accept the Sinclair 16k RAM pack and up to three plug-in modules. You will need four PC edge connectors 2 x 23 way (RK35Q) and the pcb. See page 47 for prices.

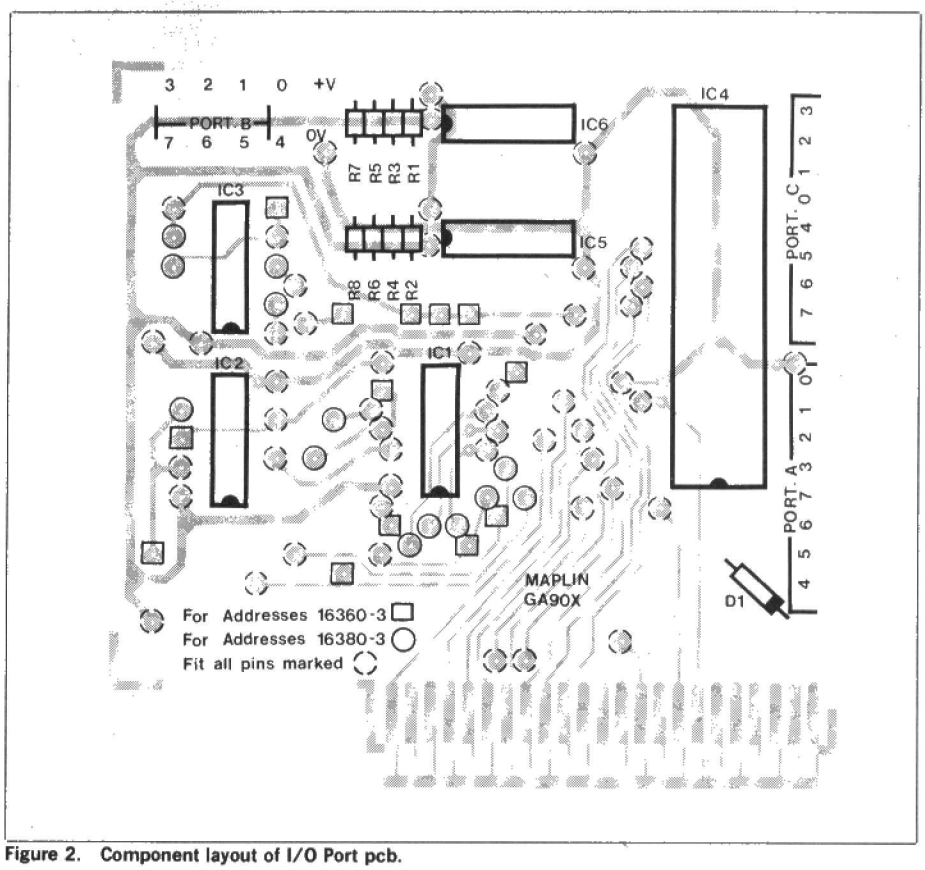



Figure 2. Component layout of I/O Port pcb.

**DEMO 1**

```
  1 REM   A. DAYKIN.
  5 REM   PORT DEMO NO. 1
 10 POKE 16363,128
 20 LET A=0
 25 SCROLL
 30 PRINT A
 40 FOR L=1 TO 50
 50 POKE 16361,A
 60 NEXT L
 70 LET A=A+1
 80 SCROLL
 90 IF A>=16 THEN GOTO 20
100 GOTO 30
```

**DEMO 2**

```
  1 REM   A. DAYKIN.
  5 REM   PORT DEMO NO. 2
 10 POKE 16363,153
 20 LET A=0
 25 SCROLL
 30 PRINT "PORT B OUTPUT IS  ";A
 35 SCROLL
 40 FOR L=1 TO 50
 50 POKE 16361,A
 60 NEXT L
 70 LET A=A+1
 80 IF A<16 THEN GOTO 25
 90 SCROLL
100 PRINT "PORTS A AND C WILL BE"
105 SCROLL
110 PRINT "TESTED AS INPUTS"
120 LET B=PEEK 16360
125 SCROLL
130 PRINT "PORT A READS  ";B
140 SCROLL
150 LET C=PEEK 16362
160 SCROLL
170 PRINT "PORT C READS  ";C
180 STOP
```

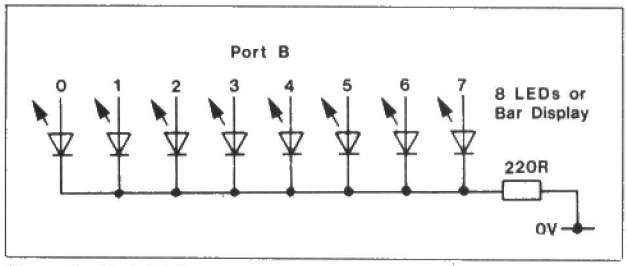



Figure 3. Test LED's.

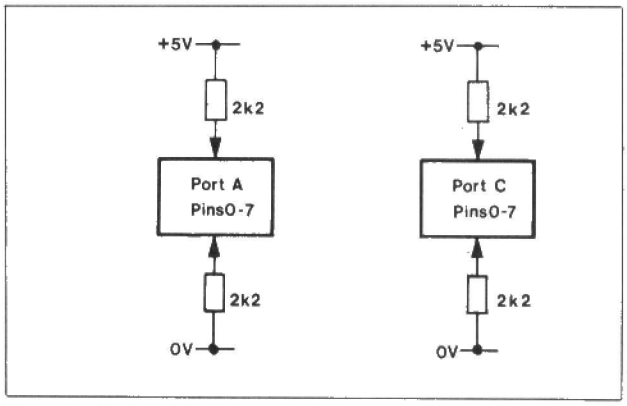
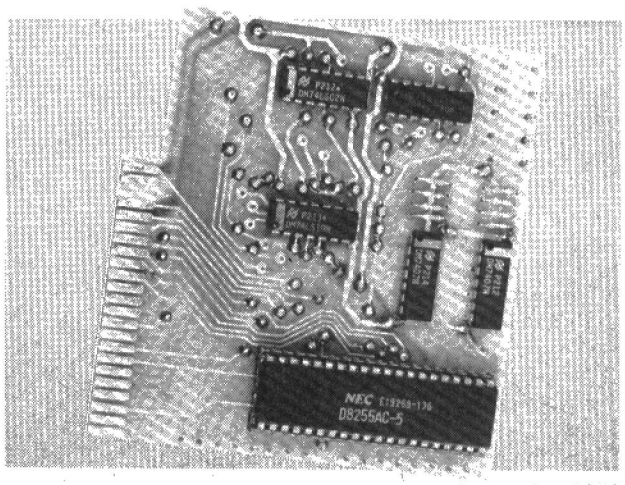



Figure 4. Test resistor connections.



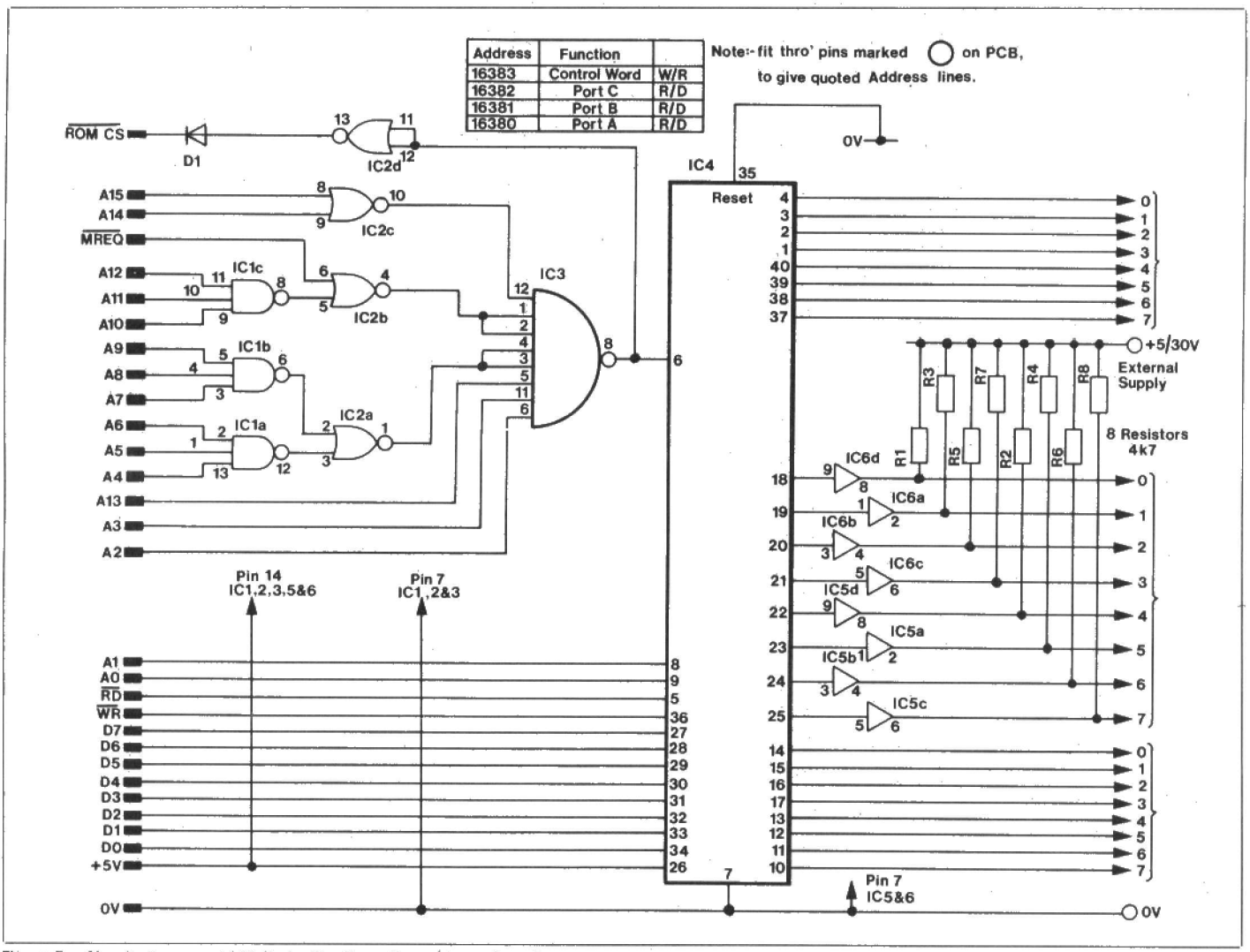



**Figure 5. Circuit diagram of I/O Port with alternative address decoding.**

# MAPLIN TRAIN CONTROLLER PROGRAM FOR ZX81

**by Dave Goodman**

This program has been designed for use with the ZX81 1k or 16k RAM and our I/O port interface PCB.

Port address used is "16361", and the POKE command in line 3 simulates a track supply fail, bringing on the LED and stopping all trains.

Table 1 shows the decimal value (which, of course, appears as a binary number between 0 and 255) on the data lines.

| | A | B | C | D |
|---|---|---|---|---|
| F | 0-9 | 32-41 | 64-71 | 96-105 |
| R | 16-25 | 48-57 | 80-89 | 112-121 |

**Table 1. Direction and speed.**

So, if controller "A" is required to move a train in a forward direction at a 'snails pace' speed of 1, then the decimal code set up will be 1.

Similarly, to select controller "D" with reverse direction and speed at maximum (9), the required decimal code will be 121.

Type in the program, followed by RUN and NEW LINE. Two statements are printed. The first, EMERGENCY STOP E, allows key E, when pressed, to stop all trains running at any time, and the second, CONTROLLER A-D?, X TO CHANGE, allows you to select the required train control unit A, B, C, or D. Pressing key X allows you to re-select a control unit.

Select a control unit (A-D) and note that a third statement is added, DIRECTION F/R?.

```
 1 POKE 16363,128
 2 LET E "16361"
 3 POKE E, 128
 4 CLS
 5 PRINT "Emergency STOP E"
 6 PRINT "Controller A-D?, X To change"
 7 GOSUB 100
 8 IF C$<"A" OR C$>"D" THEN GOTO 7
 9 LET D$=C$
10 PRINT "Direction F/R?"
11 GOSUB 100
12 IF C$="F" OR C$="R" THEN GOTO 14
13 GOTO 11
14 LET E$=C$
15 IF E$="F" THEN LET H=0
16 IF E$="R" THEN LET H=16
17 PRINT "Speed 0-9?"
18 GOSUB 100
19 IF C$<"0" OR C$>"9" THEN GOTO 18
20 IF D$="A" THEN POKE E, VAL C$+H
21 IF D$="B" THEN POKE E, VAL C$+H+32
22 IF D$="C" THEN POKE E, VAL C$+H+64
23 IF D$="D" THEN POKE E, VAL C$+H+96
24 GOTO 4
100 IF INKEY$<>"" THEN GOTO 100
101 IF INKEY$ ="" THEN GOTO 101
102 LET C$= INKEYS
103 IF C$="E" THEN GOTO 3
104 IF C$="X" THEN GOTO 4
105 RETURN
```

Now that you have selected a controller the direction of travel is needed. Press key F for forward, key R for reverse.

Finally a fourth statement is added, SPEED 0-9?. Now that control and direction are set, train speed must be chosen. Note that speeds minimum (0, stopped) to maximum (9) are set by keys 0 to 9 in either forward or reverse. Press a number, and the code corresponding to all variables will set the train running. The screen will then return to the first two statements, waiting for A-D, F-R, and 0-9 to be input again. Remember that E (panic), and X (train controller) can be pressed at any stage, and that NEWLINE is not required during the program. Under normal conditions the program should be found to be crashproof, and entry to the program is made by pressing the BREAK key (D/101) and NEWLINE.

Connections from the I/O port PCB to the train control remote latchboard are as follows:—

| I/O port B pins | Remote data latch PCB pins |
|---|---|
| 0 | 28 - B5 |
| 1 | 27 - B6 |
| 2 | 30 - B4 |
| 3 | 31 - B0 |
| 4 | 32 - B1 |
| 5 | 33 - B2 |
| 6 | 34 - B3 |
| 7 | 26 - B7 |
| 0V | 28 - B5 |

The +5V supply for the I/O port buffers IC5 and 6 can be taken from the ZX81 +5V supply.

# COMPUTER NEWS

## K-DOS

**A better disk operating system for your Atari computer.**

Have you been programming with an ATARI disk based system for some time? Are you irritated by the need to load the second stage of DOS II even to look at the directory of a diskette? Are you frustrated by seeing the screen fill with a menu that you already know? If so, read on.

K-DOS is an exciting new disk-operating system for the ATARI 400/800, which can transform your ATARI from a machine which treats you and the novice as equals into a professional-style system.

K-DOS, from K-Byte, is supplied with a concise manual, which has all the functions laid out in an easily understood format. Booting up the supplied disk will load K-DOS in the usual manner. A successful boot is indicated by the K-Byte identification header. The BASIC cartridge, if present, is then initialised, and control is transferred to it, with the appropriate READY sign. The usual format AUTO RUN.SYS file is supported, and would have been loaded and executed by this stage. Assuming that BASIC is present, one may simply type the usual DOS command to enter DOS control. The immediate confirmation of this is the echoing of DOS two lines down in lower case characters. The two obvious advantages at this stage are:—

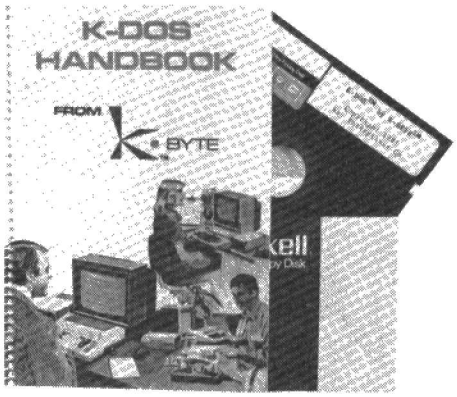
1. There is no delay in entering DOS, as it is present in its entirety.

2. The screen is not blanked, then filled with a redundant menu; the screen simply scrolls when the cursor reaches the bottom line.

A directory is obtained by typing 'DIRECT' or its abbreviation 'D', then hitting the return. This results in the listing as normally produced by ATARI's own DOS. Returning to BASIC is just a matter of typing 'BACK' or its abbreviation 'B', whereon BASIC is entered as usual, but with the difference that the screen is not cleared — a very useful point for those of us with memories like sieves, and who, like myself, are continually forgetting filenames!

Just as it is possible to return to BASIC by hitting (SYSTEM RESET), so is it also possible to go to K-DOS by holding down the (START) key and simultaneously pressing (SYSTEM RESET). This is a nice fast method of entering K-DOS, and is very cleverly done; great if you do not require the contents of the screen to be retained.

K-DOS not only supports all the usual functions of DOS II, i.e. copy file, rename file, delete file, lock and unlock, write DOS file (WB00T), format disk etc., but also provides




### COMMAND SUMMARY

| | |
|---|---|
| Disk Maintenance | INIT n<br>FORMAT n<br>WBOOT {n}<br>*DISKdup {scr{,}dest}{/A}{/W}<br>{/F}{/P}} |
| File Control | Direct {filespec}{,output}<br>Copy input {,output}<br>DELete filespec {/N}<br>LOCk filespec<br>UNlock filespec<br>REName file,filename<br>APpend {sourcefile,} destfile<br>*TRansfer filename {/SIRG}<br>{,filename}{/SIRG} |
| Program Control | Back<br>WARM<br>COLD<br>Xit<br>UNLOAD<br>LOMem<br>DC {character} |
| Machine Monitor | Run file {/M}{/N}{/P}<br>Load file {/M}{/N}{/P}<br>Save file {/A} beg end {{init} start}<br>Go {hhhh}<br>Proceed {hhhh}<br>Examine { ◄first ► {, ◄last ► }}<br>Alter {adr}{ ◄} hex....or "ascii<br>REgister {r ◄h} |
| Device Control | RESET<br>Text<br>CLose<br>ERror nn |
| DUP Special | *UDC<br>Ident<br>KILL<br>REVIVE |

_____ Indicates the minimum abbreviation.

* Indicates a UDC command that normally resides in a disk file.

a whole host of additional ones, which are listed here.

As you can see, commands consist of logical English words. Most of these will have an abbreviation, usually of one or two characters (the minimum abbreviation is shown underlined). Many of the commands shown will have option switches, which may alter the way in which the command is executed. One example of this is the LOAD command. This loads a binary file into memory from disk, and the three option switches are:—

/M which causes the printing to the screen of the area of memory into which the file is loading, as well as the INIT. and RUN addresses.

/N will prevent the file from being run, and

/P will allow the file to overlay an area of DOS, an event which would normally produce an error trap.

Speaking of errors, another of the K-DOS features is the production of proper English error messages, e.g. ERROR 138, DEVICE TIMEOUT, or ERROR 1, ILLEGAL COMMAND. The text for these error reports can be changed easily by using one of the utility files on the supplied disk (CHERROR.SYS), allowing the creation of highly amusing and lively error statements!

One of the nice facilities for large business systems is the ability to define a command to run a particular machine code program. The 'UDC' (User Defined Command) program supplied permits the assignment of one or more character names, which when typed call up and run the designated file — pretty neat, eh?

Another interesting function of K-DOS is its disk duplicate utility. Whereas the DOS II DUPDISK command does not actually duplicate an entire disk, merely its file structure. DUPDISK with K-DOS has an option switch, /A for ALL, which causes the duplication of every single sector of a disk — a true disk duplicate.

A similarly well-written file utility is also supplied, and this is called TRANSFER. This is a file transfer utility primarily for copying files from one device to another, and files from one disk to another using the same drive. A special feature is that it will load from cassette to disk, a file or program written with short inter-record gaps e.g. auto-boot cassette programs, as well as reading and writing those with long IRGs.

These are just a few of the functions that K-DOS offers, but as can be seen from the list they represent only a small part of what is available. All of these commands can actually be used from BASIC without actually going 'into' DOS. Simply type a comma before the command, and hey presto!, it is executed from BASIC (e.g., D will produce a directory listing whilst still under BASIC cartridge control).

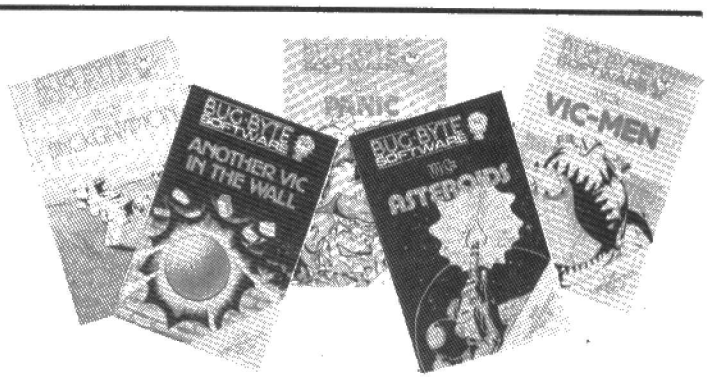
K-DOS, it seems, represents a major step forward for the serious ATARI programmer, in that:—

1. It provides a very powerful set of monitor and disk commands and 2. It is fast and logical to use, thus giving the user big machine features on a personal computer.

It is highly recommended by myself, indeed, I have not used ATARI's own DOS for at least three months!

## NEW SOFTWARE FOR THE VIC20

| | | |
|---|---|---|
| AC77J | (Sargon II Chess Cartridge) | **Price £24.95** |
| AC78K | (Another VIC In The Wall Cassette) | **Price £7.00** |
| AC79L | (VIC Panic Cassette) | **Price £7.00** |
| AC80B | (Cosmiads Cassette) | **Price £7.00** |
| AC81C | (Backgammon Cassette) requires at least 3k expansion | **Price £7.00** |
| AC82D | (VIC-Men Cassette) | **Price £7.00** |
| AC83E | (VIC Asteroids Cassette) | **Price £7.00** |



# THE ATARI 400/800

## ARE THE BEST HOME COMPUTERS AVAILABLE and here's why! *by Ron Levy*

The majority of microcomputer purchasers are buying for the first time. When they look at what is available, they find a vast bewildering range of machines to choose from. Each manufacturer claims his is the ultimate personal computer system and most are better than all the others. But these advertisements rarely give any thought to the requirements of the home user or to the practicalities of using a system at home.

The three main purposes of a home computer are education, personal software development and entertainment. The educational aspect requires that the machine be well-designed in terms of ease of use, with good documentation and tutorials with the appropriate software back-up to make learning enjoyable. For personal software development, the machine needs to be fully expandable to a complete system with disk drive, printer and cassette recorder etc. without masses of interfacing circuitry, wiring looms or the need for extra chips to be added.

The entertainment aspect is usually of equal importance (certainly when impressing friends or getting the rest of the family interested) and can be the most difficult to fulfill in terms of the complexity of the hardware and software involved.

To achieve these ends a home computer must be designed as a system rather than just a processor with the other parts left to be designed later. The Atari was the first personal computer to be designed specifically for home use. It was conceived as a complete system. Many people purchase low-priced personal computers only to find that to make it do anything worthwhile involves great expense for memory or hardware expansion. Memory for the Atari is relatively inexpensive and hardware expansion does not require expensive interface units. Everything just plugs directly one into another.

## Graphics

But the one outstanding virtue of the Atari computers, both in terms of personal software development, education and entertainment is its graphics capabilities. These are quite simply unrivalled on any machine costing under £3,000.

The ZX Spectrum and The BBC micro uses Ferranti's Uncommitted Logic Arrays (ULA) to extend the power of the main processor (6502). These are quite powerful chips, but they do not approach the power of a real microprocessor. The reason they are used is because they are many many times cheaper to design than a complete microprocessor, but clearly if it was a viable proposition a microprocessor would be far more powerful. Atari are owned by the giant Warner Bros. Corporation who spared no expense in the design of the Atari computers. They designed a microprocessor (and called it 'ANTIC'), specifically to control the TV display, and the Atari therefore has two microprocessors and, as we said, the most brilliant graphics as a result.

But Atari didn't stop there. On top of that there is still another chip that has a hand in the control of the TV display. This chip, called a GTIA, provides a function known as Player Missile Graphics, and it's this concept that makes those amazing arcade games so clever.

With the GTIA, the programmer is able to create an object on the screen in any desired shape and simply designate the shape, a player and missile number. This object does not, however, exist as part of the screen memory known to ANTIC, but is in fact an entirely separate entity having its own separate area of memory which can then be manipulated and superimposed on the display by the GTIA.

These player/missiles can then be assigned a priority relative to the background or other objects so that they move behind or in front of different objects without further intervention. The colours, positions and even the shapes of these player/missiles can also be changed and on the display, the changes appear instantaneously while the 6502 and ANTIC get on with their jobs uninterrupted. It is these major advantages of the Atari computers, that put Atari graphics leagues ahead of any other computer under £3,000. The Atari makes graphics control easy, colourful and above all permits objects to move with incredible speed and smoothness around the screen, or complex objects to be repositioned instantaneously.

The story does not end there, however, for the Atari has yet another specially designed extremely powerful IC called POKEY. This amazing chip deals with serial input/output, keyboard scan, audio generation, random number generation and analogue to digital conversion.

The Atari has four separate sound generators and on each one the pitch and volume are controllable. Any may be used to produce noises, squawks, bangs, rattles, hisses etc. No other personal computer in the Atari's price range has such a versatile sound generator system.

A look at the front of the machines shows the four joystick ports. As well as being joystick ports, these present one of the easiest methods of interfacing to a computer because they are bi-directional (i.e. they can be used as inputs or outputs) and can be addressed simply as memory locations. Each socket also has two analogue to digital converter inputs (giving a total of eight) that could be used by those wishing to experiment with add-on hardware for robot control for example.

On the side of the machine is the serial input/output port (SIO) to which the peripheals, disk drive, printer, etc. can be connected. And again, this has been designed with the home user primarily in mind, for from this one neat little socket, peripherals may be connected, each extra one just plugging into the one before, obviating the need for interface boxes or dozens of cables. Each device has its own command data frame so that even though they are all connected together there are no problems with the software talking to the particular device required.

One of the major criticisms levelled against the Atari computers by manufacturers and owners of other machines is that the Atari 400/800s are "just games machines". It is a comment given exclusively by people who haven't the faintest idea what they're talking about.

## Atari Cassette System

Those who know the Atari will find the comment devoid of any serious consideration, for how many other machines can control up to four disk drives, a printer, a professional multi-channel RS232/Centronics (i.e. non-Atari) interface and communications box and a cassette recorder, simultaneously without further interfacing or hardware and without any hardware or software conflicts or problems of any sort?

Another unique feature of the Atari computer is the way it handles its cassette recorder. The Atari cassette recorder is in fact a two-track device. One track is the data signal as with all other computers, but the other track is used for storing a soundtrack. This brilliant, yet simple idea puts the Atari's educational capabilities in a class of its own!

In Atari's own software, it is used to great effect in the 'Learn Programming' and language learning cassettes. With a single POKE statement, it is possible to transfer the audio track to the TV speaker, thus making controlled commentary a possibility with learning programs on the Atari. I wonder how many people realise that the first "Bonjour" you hear in Atari's TV advertisement is actually spoken by the computer!

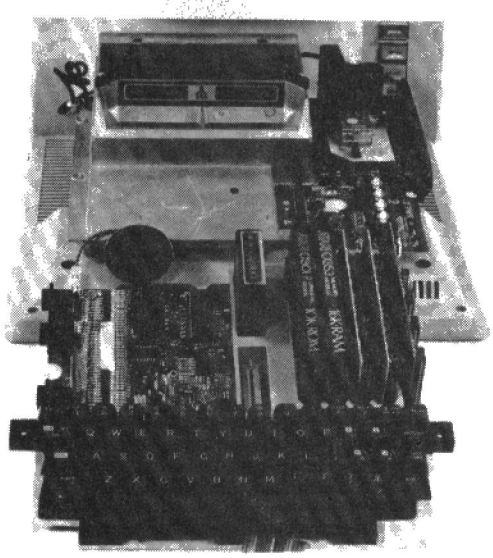
Another key feature of the Atari cassette system is that it is possible to increase or slow down the tape drive speed through several times its normal speed without affecting data loading. Data will still load correctly because at the start of every 128-byte block of data there are two additional bytes that are used by the operating system in a very smart piece of software that calculates the baud rate of the tape being loaded. The result is that manufacturing tolerances in the speed and construction of the tape unit and the tapes, have no detrimental effect upon reliability of operation.

The physical construction of the Atari 400 and 800 is very attractive and modern. A heavy-duty plastic moulding is used for the external cabinet and will withstand a good deal of rough treatment unlike the majority of micros currently available. A look inside the machine reveals the fact that the entire CPU and its RAM cards are encased in a die-cast aluminium alloy moulding. Consequently there is very little radiation or interference from the computers and conversely Atari computers do not suffer from system crashes caused by external interference.

The quality and quantity of software for the Atari also far exceeds that of any other personal computer for two very good reasons. Firstly, since the machine is so comprehensive in its graphics facilities, it attracts the best programmers and secondly because the Atari makes it easy to protect software very well against unauthorised copying, producers of software are able to invest time and money developing good programs knowing they will get a fair return from it.
There is already masses of software available for the Atari, from the latest arcade games to complex languages like LISP and FORTH. Over 30 software houses in America are busily writing software for the Atari and others are adapting Apple software. The Atari's are currently America's best-selling computer — the Americans at least have found out how good it really is!

## Sinclair's Advertising

Finally, let's take a look at Sinclair's six-page advertising brochure which has been inserted in most of the computer magazines in recent months. In the leaflet, there is a table comparing the ZX Spectrum with the BBC micro, VIC20, Atari 400, TI99/4A and TRS80 Colour computers.
Taking the chart line by line, the first point to note is that the Atari 400 is now a little cheaper than shown, but is still about twice the price of the Spectrum both for the 16k and 48k versions. Nevertheless, we still believe that if you can afford it, the Atari gives you more for your money. When you're fed up with the relatively low quality and quantity of Spectrum software and fed up with the much lesser capabilities of the Spectrum, you'll still be finding new, exciting things to do on the Atari.
The line showing standard RAM available using hi-res graphics is a cunning way of making a bad point look good. The reason the Spectrum has more RAM left than the BBC or Atari is that its highest resolution is less than the BBC or Atari so naturally it has more RAM left.



The highest resolution on the Spectrum, Atari and BBC is as follows respectively: 256 x 192, 320 x 198, and 640 x 256. The BBC machine looks very good here, but using its highest resolution you do only have 3k of RAM left and you can only use two colours on the screen, so you can't do a lot with it. Even on the BBC model B you only have about 10k of RAM left. On the 48k Atari you have 30k of RAM left (nearly 40k if you're not using BASIC) and with this or 16k RAM you can have at least six colours at once.
But, in any case, the ability of a computer is not directly related to its highest possible resolution. On the Atari, most of the best games use low resolution graphics modes.
The next line on Sinclair's chart compares maximum memory and although Sinclair could not have known at the time Maplin can now supply Atari 400's with 48k RAM fitted.
To directly compare the Atari or BBC's sound generators with the Spectrum is ridiculous. Both are far and away superior to the Spectrum's one sound generator. The BBC has three and a noise channel and the Atari has four with volume and noise software adjustable on all four.

The number of colours available on the Atari is 16, but each can be displayed in 16 intensity levels which does give the impression of being different colours and it is in fact possible, though not easy, to display all 256 colours and levels on the screen simultaneously.
This fact then makes the next line on Sinclair's chart look pretty ridiculous since he claims you can only have 5 colours on the screen at one time. This is simply not true. Even in the highest resolution mode you can have six colours on the screen at once (there is usually a trade off between resolution and numbers of colours available). Another major advantage with the Atari is that different parts of one picture can actually be in different resolution modes simultaneously! — So the possibilities with the Atari really are far in advance of any other machine on this table. To be fair, comparing the graphics on the Spectrum with the graphics on the Atari is like comparing Meccano with the Empire State Building.
Flash is not available from the keyboard on the Atari, but is so easily implemented in software that it's not a factor worthy of serious consideration when choosing a computer.
Surprisingly Sinclair do not think the Atari has user-definable graphics characters, but don't worry, it has — and what you can do with them on the Atari is of course far, far better than on the Spectrum.
The only other point worthy of note is that the Atari cannot interface a normal cassette recorder, but as we've pointed out, the advantages of the Atari system far outweighs this fact.
The Atari is a very clever computer and if we had more space we could go into even more detail about its amazing capabilities. It can be used as a business machine, but it's not ideal; it wasn't designed to be. It was designed to be a home computer and this is where it excels. It was designed to be a complete system. It has got an enormous amount of software back-up.
It is the world's best home computer — and that's a fact!

# NEW SOFTWARE FOR ATARI

This month we're pleased to announce another massive selection of titles available for the Atari computers.

**Adventure Games**

| | | |
|---|---|---|
| Ali Baba & The Forty Thieves | -D-32K-(BQ78K) | £27.95 |
| Star Warrior | -D-32K-(BQ79L) | £28.95 |
| Rescue At Rigel | -D-32K-(BQ80B) | £22.45 |
| Invasion Orion | -D-32K-(BQ81C) | £18.95 |
| Datestones of Ryn | -D-32K-(BQ82D) | £14.95 |
| Crush, Crumble and Chomp | -C-32K-(BQ83E) | £22.48 |
| Crush, Crumble and Chomp | -D-32K-(BQ84F) | £22.48 |
| Temple of Apshai (Part 1) | -C-32K-(BQ85G) | £28.95 |
| Temple of Apshai (Part 1) | -D-32K-(BQ86T) | £28.95 |
| Upper Reaches of Apshai (Part 2) | -C-32K-(BQ87U) | £14.95 |
| Upper Reaches of Apshai (Part 2) | -D-32K-(BQ88V) | £14.95 |
| Curse of Ra (Part 3) | -C-32K-(BQ89W) | £14.95 |
| Curse of Ra (Part 3) | -D-32K-(BQ90X) | £14.95 |
| Mission: Asteroid | -D-40K-(BQ91Y) | £17.19 |
| Ulysses & The Golden Fleece | -D-40K-(BQ92A) | £20.64 |
| Softporn Adventure | -D-40K-(BQ93B) | £20.64 |
| Zork I: The Great Underground Empire | -D-32K-(BQ94C) | £29.95 |
| Zork II: The Wizard of Frobozz | -D-32K-(BQ95D) | £29.95 |
| Deadline | -2D-32K-(BQ96E) | £34.95 |
| The Battle of Shiloh (war game) | -D-40K-(BQ97F) | £29.95 |
| The Shattered Alliance (war game) | -D-48K-(BQ98G) | £29.95 |

**Teach Yourself Programs**

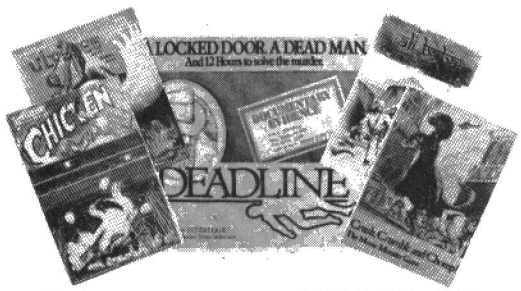
| | | |
|---|---|---|
| Kids 1 (3 programs) | -C-16K-(BG00A) | £9.95 |
| Kids 1 (3 programs) | -D-24K-(BG01B) | £9.95 |
| Kids 2 (3 programs) | -C-16K-(BG02C) | £9.95 |
| Kids 2 (3 programs) | -D-24K-(BG03D) | £9.95 |

**Learn Programming**

| | | |
|---|---|---|
| Sound | -C-16K-(BG04E) | £11.95 |
| Sound | -D-24K-(BG05F) | £11.95 |
| Tricky Tutorials (all 6 in binder) | -C-32K-(BG06G) | £59.95 |
| Tricky Tutorials (all 6 in binder) | -D-32K-(BG07H) | £59.95 |

**Business Programs**

| | | |
|---|---|---|
| Text Wizard | -D-32K-(BQ99H) | £69.95 |




| | | |
|---|---|---|
| Mini Word Processor | -C-32K-(BG08J) | £9.95 |
| Mini Word Processor | -D-32K-(BG09K) | £11.95 |
| File-It 2 | -D-48K-(BG10L) | £34.95 |
| Bob's Business (14 programs) | -C-32K-(BG11M) | £9.95 |
| Bob's Business (14 programs) | -D-32K-(BG12N) | £9.95 |

**Arcade Games**

| | | |
|---|---|---|
| Pacific Coast Highway | -C-16K-(BG13P) | £24.95 |
| Pacific Coast Highway | -D-16K-(BG14Q) | £24.95 |
| Shooting Arcade | -C-16K-(BG15R) | £24.95 |
| Shooting Arcade | -D-16K-(BG16S) | £24.95 |
| Jawbreaker | -C-16K-(BG17T) | £20.64 |
| Threshold | -D-40K-(BG18U) | £27.54 |
| Shooting Gallery | -D-16K-(BG19V) | £16.95 |
| Race In Space | -D-16K-(BG20W) | £16.95 |
| Ghost Hunter | -D-16K-(BG21X) | £22.95 |
| Crossfire | -C-16K-(BG22Y) | £20.64 |
| Crossfire | -D-32K-(BG23A) | £20.64 |
| Protector | -C-32K-(BG24B) | £22.95 |
| Protector | -D-32K-(BG25C) | £22.95 |
| Star Trek 3.5 | -D-40K-(BG26D) | £18.95 |
| Chicken | -C-16K-(BG27E) | £22.95 |
| Chicken | -D-16K-(BG28F) | £22.95 |
| Dodge Racer | -C-16K-(BG29G) | £19.95 |
| Dodge Racer | -D-24K-(BG30H) | £19.95 |
| Matchracer | -C-16K-(BG31J) | £23.95 |
| Matchracer | -D-16K-(BG32K) | £23.95 |
| Pathfinder | -D-32K-(BG33L) | £27.95 |
| Deluxe Invaders | -D-16K-(BG34M) | £29.95 |
| Raster Blaster | -D-32K-(BG35Q) | £22.95 |
| Bug Attack | -C-24K-(BG36P) | £23.95 |
| Bug Attack | -D-40K-(BG37S) | £23.95 |
| Haunted Hill | -C-16K-(BG38R) | £16.95 |
| Haunted Hill | -D-16K-(BG39N) | £19.95 |
| Time Bomb | -C-16K-(BG40T) | £10.95 |
| Time Bomb | -D-24K-(BG41U) | £12.95 |
| Space Chase | -C-16K-(BG42V) | £10.95 |
| Space Chase | -D-24K-(BG43W) | £12.95 |
| Canyon Climber | -C-16K-(BG44X) | £24.95 |
| Canyon Climber | -D-16K-(BG45Y) | £24.95 |
| Tumble Bugs | -D-24K-(BG46A) | £24.95 |
| Ricochet | -C-16K-(BG47B) | £14.95 |
| Ricochet | -D-32K-(BG48C) | £14.95 |
| Lunar Lander | -D-24K-(BG49D) | £14.95 |
| Angle Worms | -C-8K-(BG50E) | £10.95 |
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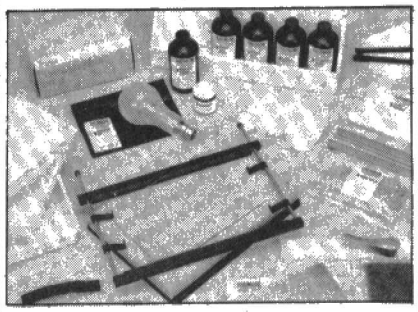

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## WORKING WITH OP-AMPS (Continued from Page 13)

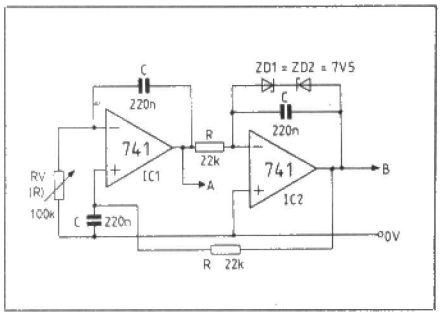


**Figure 11. The quadrature oscillator.**

### The Sine-Square Converter

Having produced the required sinewave, the next step is to square it off. A very simple way of doing this is to use the op-amp comparator, shown in Figure 10. The inverting input is tied to 0V and the sinewave input is applied to the non-inverting input. Every time the input goes positive, even by a fraction of a milli-volt, the output goes into positive saturation, and for negative half-cycles at the input, the output goes into negative saturation. So the sinewave is very efficiently converted into a square-wave, which can then be integrated, using a standard op-amp integrator, to develop the triangular waveform.

### The Quadrature Oscillator

Having dealt now with several circuits that produce different time-related waveforms, it is interesting to consider a circuit in which the waveforms are identical but differ by a fixed phase angle, whatever the frequency. The actual phase angle is 90° so that the sinewaves are in 'quadrature', hence the name of the circuit, which appears in Figure 11. Two integrators are used, IC1 and IC2, the former being a non-inverting type and the latter an inverting type. The frequency of the output waveforms is determined by the time constants obtained from three resistors and three capacitors, known as R and C respectively on the basis that they are nominally equal. In practice, one of the resistors is a potentiometer RV, which is carefully adjusted until the given outputs A and B are obtained, best viewed on a double-beam CRO. If RV is turned too far one way, the circuit stops oscillating, and if too far the other way, the waveforms become a triangle and a square-wave! However, the correct setting of RV is easily found and the sinewaves are then quite stable and of excellent waveform. An amplitude limiter is included in the form of two zener diodes connected back to back.

The formula for the frequency of operation is that $f=1/(2\pi R.C)$ and, with the values given in Figure 11, the circuit oscillated at 33Hz. It will work quite happily over a wide range of frequencies. For example, with R=47k; C=220n, the frequency is as low as 14Hz and with R=1k; C=47n, the frequency is then 3.7kHz. At the higher frequencies a smaller value of RV makes the setting less critical.

## AMENDMENTS TO CATALOGUE

The following points have come to our notice since the last issue of this magazine.

**Page 20**
The picture of the 2m Rubber Duck (YG15R) shows a UHF plug, but the item is supplied with a BNC plug as stated in the text.

**Page 47**
The Lift-off Hinge (YL04E) is now cadmium-plated, not chrome-plated.

**Page 84**
Euroboard 4-way (WY16S) does not have a neon indicator.

**Page 125**
Pan Neon Amber (RX82D) now has a small square face.

**Page 145**
Photo-Etch PCB (BW19V) is now being supplied in a smaller size: 160 x 100mm (Eurocard size).

**Page 258**
For WQ18U we are now supplying AY-3-1015D. This IC is directly equivalent to AY-5-1013A except that it requires only a single 5V supply. Therefore no connection must be made to pin 2.

## CORRIGENDA

### ZX81 KEYBOARD KIT AMENDMENT

**Additions To 'Connecting To ZX81'**

Before connecting the keyboard to your ZX81, use a meter set to read d.c. volts and measure between 0V and pins 1 to 8 (SK2), and pins 1 to 5 (SK1) in turn. This test must be performed with the power supply plugged in and switched on, and without the keyboard connected to the ZX81. There should be no voltage present at these pins until a key is depressed.

**VIC20 Programs Corrected**

**Colour Demonstration Program**

```
10 PRINT ⌂
20 FOR D = 7680 TO 8185 : POKE D, 224 :
   NEXT D
30 C = INT (RND(1)x506) + 38400
40 A = INT (RND(1)x8) : IF A<1 THEN 40
50 POKE C, A : GOTO 30
```

**Joystick Demonstration Program**

```
10 PRINT ⌂ : X = 7680 : Z = 0 : V = 1 : POKE
   37154, 127
20 FOR C = 38400 TO 38960 : POKE C, 6 :
   NEXT C
30 A = PEEK (37151) : POKE X, 224
40 IF A = 122 THEN X = X-22 : V = V-1 :
   IF V<1 THEN X = X+22 : V = V + 1
50 IF A = 118 THEN X = X+22 : V = V+1 :
   IF V>23 THEN X = X-22 : V = V-1
60 IF A = 110 THEN X = X-1 : Z = Z-1 :
   IF Z<0 THEN X = X+1 : Z = Z+1
70 IF PEEK (87152) = 119 THEN X = X+1 :
   Z = Z+1 :
   IF Z>21 THEN X = X-1 : Z = Z-1
80 GOTO 30
```

**Other Amendments**

Issue 3 Page 20 Figure 5a
R5 should be a 47k, not a 100k as shown.
R16 should be an 820R, not a 4k7 as shown.


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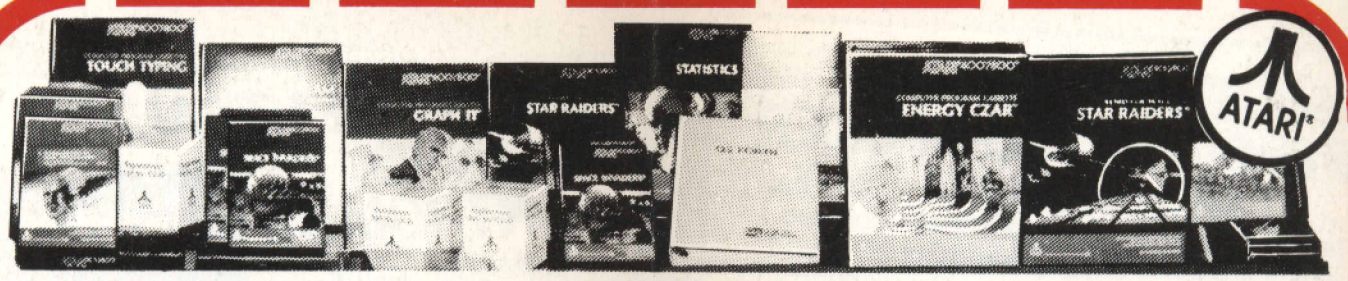


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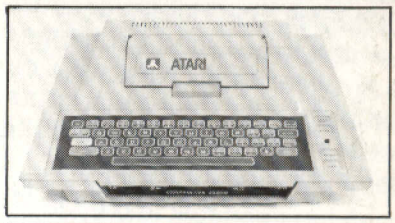

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